[COMMITTEE PRINT]

SPACE ACTIVITIES OF THE UNITED STATES, SOVIET UNION, AND OTHER LAUNCHING COUNTRIES/ORGANIZATIONS, 1957-1984

REPORT

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FOR THE

SUBCOMMITTEE ON
SPACE SCIENCE AND APPLICATIONS

TRANSMITTED TO THE

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SCIENCE AND TECHNOLOGY
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**Serving on Committee on the Budget for 99th Congress.

LETTER OF TRANSMITTAL

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, DC., April 22, 1985.

To All Members, Committee on Science and Technology:

There is transmitted herewith a Congressional Research Service updated report entitled, "Space Activities of the United States, Soviet Union and other Launching Countries/Organizations 1957–1984." The report is based on careful analysis of information contained in numerous unclassified sources. It will be helpful to all readers interested in the changes and developments in the U.S. space program when compared with other nations.

I commend the report to your attention.

Sincerely,

DON FUQUA, *Chairman.*

LETTER OF TRANSMITTAL

Hon. DON FUQUA,
Chairman, Committee on Science and Technology,
House of Representatives, Washington, DC.

DEAR MR. CHAIRMAN: I am pleased to submit to the Members of the Committee a report prepared by the Congressional Research Service "Space Activities of the United States, Soviet Union, and Other Launching Countries/Organizations: 1957–1984."

The report places into perspective the economic competition the United States faces from other nations in providing space services and hardware. Information contained herein provides useful statistical and programmatic summaries of the space activities of other launching nations. I commend it to your attention.

Sincerely,

BILL NELSON,
Chairman, Subcommittee on
Space Science and Applications.

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Washington, D.C. 20540

LETTER OF SUBMITTAL

April 9, 1985

Honorable Bill Nelson
Chairman, Subcommittee on
Space Science and Applications
Committee on Science and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

Pursuant to your request, we are providing a copy of the CRS report Space Activities of the United States, Soviet Union and Other Launching Countries/Organizations 1957-1984 for republication as a committee print. This report is an updated version of the edition published last year and covers events through December 31, 1984.

The report was updated by Marcia S. Smith, Specialist in Aerospace and Telecommunications Systems of the Science Policy Research Division. Mr. Geoffrey E. Perry, head of the Kettering Group in England, also contributed information for the report.

We hope that these annual reports continue to be helpful to your subcommittee in its oversight of NASA's space activities. If we can be of further assistance, please let us know.

Sincerely,

Gilbert Gude
Director

Congressional Research Service
The Library of Congress

Washington, D.C. 20540

SPACE ACTIVITIES OF THE UNITED STATES, SOVIET UNION AND OTHER LAUNCHING COUNTRIES/ORGANIZATIONS: 1957-1984

Marcia S. Smith
Specialist in Aerospace and Telecommunications Systems
Science Policy Research Division

January 31, 1985

(IX)

ABSTRACT

Five countries and one international organization currently have the capability to place satellites in space. The United States and the Soviet Union conduct the most comprehensive programs, and have been launching spacecraft for both military and civil purposes for over 25 years. The entry of countries such as Japan and the members of the European Space Agency into the space business has now introduced the element of economic competition in providing space services and hardware. This annual report reviews the space activities of the launching countries/organization--China, the European Space Agency, India, Japan, the Soviet Union, and the United States--both statistically and programmatically. This edition covers events through December 31, 1984, and highlights significant activities in 1984.

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EXECUTIVE SUMMARY

1984 SPACE ACTIVITIES AND 1985 PROSPECTUS

A new world record of launches which successfully attained earth orbit was set in 1984 — 129, compared to 128 in 1976. Of these, 97 launches were made by the Soviet Union, 22 by the United States, 4 by the European Space Agency and Arianespace (a private company which now launches the Ariane), 3 by Japan, and 3 by China. Three of these launches, however, apparently suffered upper stage failures so the payloads did not go into their proper orbits (1 each for the Soviet Union, United States and China). They reached orbit, however, so are counted as launch "successes," while their payloads are counted as "failures" in the tables which follow.

A. MANNED SPACE ACTIVITIES

1. Soviet Union: Setting New Records, Claiming New Firsts

The Soviet Union set two new records in their manned program during 1984: extending the mission duration of a single crew to 237 days (the previous record of 211 days was set by a Soviet crew in 1982); and the cumulative time spent by cosmonauts on extravehicular activity (EVA) on one mission (22 hours 50 minutes, compared to the record of 22 hours 25 minutes set by the U.S. Skylab 4 crew in 1974). The Soviet crew accumulated that time during 6 EVAs; the U.S. crew had performed 4 EVAs.

One of the crews that visited the long duration crew included Svetlana Savistskaya who became the first woman to fly into space twice, and the first woman to perform EVA. Another visiting crew included the first

Indian (Rakesh Sharma) to fly in space.

They also had another test of their prototype, sub-scale spaceplane, although somewhat surprisingly there were no more launches of the Kosmos-1443 type module which flew in 1983, and there was no apparent attempt to rotate crews on the space station.

• Mission Duration. The Soyuz T-10/T-11 crew, comprised of three men (including a physician specializing in cardiology), remained in orbit for almost eight months. Much of their time was spent on various operational tasks such as receiving two visiting crews, unloading the five Progress ships which resupplied the space station during the year, and performing six EVAs.

• Extravehicular Activity (EVA). EVAs, or spacewalks as they are more commonly known, have been used sparingly throughout the Soviet program. Until 1983, no Soviet cosmonaut had ever performed more than one EVA on a single mission, and only two were made by the 1983 Soyuz T-9 crew. The leap to six EVAs with the very next crew could be explained by increased confidence in EVA procedures, the presence of a physician aboard the space station to monitor the crew's health, and/or the urgent need for the EVAs themselves. Five of the six EVAs were needed to repair a leaking fuel valve; the sixth involved installation of another set of new solar arrays.

• Two More Space "Firsts." In 1982, shortly before Dr. Sally Ride was to become the first American woman in space, the Soviets launched Ms. Svetlana Savitskaya as part of a visiting mission to Salyut 7. In 1984, Ms. Savitskaya made another flight into space as part of a visiting crew, shortly before Dr. Ride was to become the first woman to make two spaceflights. On her mission, Ms. Savitskaya became the first woman to perform an EVA, shortly before Dr. Kathryn Sullivan was to achieve that place

in history. While it is logical to assume that the Soviets recognize the need for fully trained women in their space program, including those experienced in EVA, the Savitskaya missions seem suspiciously timed to ensure that the Soviets, not the Americans, can claim these activities as "firsts."

- Spaceplane Tests. The fourth test of what the U.S. Department of Defense (DOD) has identified as a sub-scale prototype spaceplane was conducted in December 1984 with Kosmos 1614 which flew a flight profile very similar to Kosmos 1517 in December 1983, making a controlled descent into the Black Sea.

2. United States: Persistent Problems But Spectacular Results

The United States had five extremely successful flights of the space shuttle in 1984, but the fact that this was only half as many as had been planned drew attention to continuing problems with the shuttle system. In addition, two satellites launched from the shuttle's cargo bay did not go into correct orbits. Although the problem was with an engine attached to each satellite and not with the shuttle, the perception was that the shuttle itself had failed. All seemed better by the end of the year, however, after two astronauts on a subsequent shuttle flight retrieved the two wayward satellites and returned them to Earth for refurbishment and relaunch.

A new shuttle orbiter, Discovery, was added to the fleet, but problems with its main engines and computers delayed the first launch for two months, which was partially responsible for the reduced number of shuttle missions accomplished in 1984. Crew size increased again in 1984, with a total of seven people on one mission (STS 41-G), five men and two women, which included the commander, pilot, three mission specialists, and two payload specialists -- one of whom was Canadian.

Also in 1984, NASA was directed by President Reagan to develop a permanent presence in orbit (a space station) within a decade. NASA had been arguing in favor of a space station as "the next logical step" in the U.S. space program for several years.

- Rescuing Errant Satellites. Clearly the most spectacular success of the U.S. manned space program in 1984 was the retrieval and return to Earth of two satellites by the STS 51-A crew in November. The satellites, Palapa B-2 (owned by Indonesia) and WESTAR 6 (owned by Western Union) had gone into improper orbits in February 1984 after being deployed from the shuttle by the STS 41-B crew.

Between February and November, NASA developed procedures for retrieving the satellites, and after negotiations with the satellite owners and their insurance underwriters, an agreement was made to attempt to "rescue" them. The five-person STS 51-A crew accomplished that task using two astronauts (Joe Allen and Dale Gardner) working outside the shuttle to "catch" the satellites and stow them in the cargo bay, one astronaut (Anna Fisher) assisting them with the Remote Manipulator System (often called "the arm"), and the commander and pilot (Rick Hauck and Dave Walker) maintaining the shuttle in the appropriate orbital position and overseeing operations.

The procedure demonstrated both the versatility of the shuttle for use in retrieving payloads, and the value of having people in space for certain tasks since problems were encountered in stowing the satellites which might not have been overcome had NASA relied on automated devices.

- Repairing Malfunctioning Satellites. Only slightly less spectacular was the retrieval, repair, and redeployment of a satellite called the Solar Maximum Mission ("Solar Max") which had been launched in 1980 to study the Sun during a period of maximum sunspot activity. The spacecraft

had been the first to be launched on a spacecraft "bus" specially designed to be retrieved by the shuttle and repaired on-orbit if necessary. Solar Max malfunctioned shortly after it reached orbit, and NASA hoped that it would provide an opportunity to demonstrate the utility of the shuttle in such situations.

The retrieval of the satellite was expected to require the use of an astronaut wearing a "Manned Maneuvering Unit" (MMU) which allows the astronaut to work in space away from the shuttle without being tethered to it. The MMU was tested on the first shuttle flight of 1984 (STS 41-B) by astronaut Bruce McCandless who had been instrumental in its design and became the first person to "fly" in space. The MMU checked out perfectly, and was employed on the next mission, STS 41-C, by astronaut George Nelson who "flew" over to Solar Max and attempted to "dock" with it and return to the shuttle. Nelson was unable to grapple the satellite, however, and finally the Remote Manipulator System (controlled by Terry Hart) was used to bring Solar Max into the cargo bay where it was repaired by Nelson and James van Hoften and redeployed.

- In-Orbit Refueling. For the first time, the United States demonstrated the procedures for in-orbit refueling of spacecraft. Although the Soviet Union has routinely refueled Salyut space stations since 1978 using the unmanned Progress spacecraft under the command of ground controllers, this was the first time such an effort was attempted by the United States, and two astronauts on EVA accomplished the job.

- Women in Space. As noted above, there are still "space races" between the United States and Soviet Union, now also focussing on proving the value of women on space crews. In this "competition," Dr. Kathryn Sullivan became the first American woman to perform an EVA. On the same flight,

Dr. Sally Ride became the first American woman to fly into space twice. Two other 1984 shuttle flights included women (Dr. Judith Resnik and Dr. Anna Fisher), bringing the total to four American woman who have made spaceflights, compared to only two Soviet woman (Tereshkova in 1963 and Savitskaya in 1982 and 1984). Fisher was the first mother to fly in space; the vast majority of the male astronauts and cosmonauts have been fathers at the time of their flights.

At the end of 1984, eleven women were members of the U.S. astronaut corps and four of those who have not made flights have been assigned to missions in 1985 (the class of 1984, which includes three women, has not yet completed the training program). Savitskaya has been quoted as saying there are 10 women training in the Soviet cosmonaut corps, although none of their names have been released (the Soviets rarely announce the names of cosmonauts who have not yet flown in space, or crew assignments in advance of the mission).

• Payload Specialists. NASA continued to use the new category of "payload specialist" to provide opportunities for non-career NASA astronauts to fly in space to conduct special experiments. Although these individuals are often referred to as "non-astronauts" in the media, they are bona fide astronauts once they fly in space. It is simply that they are not career astronauts and return to their jobs once the flight is over (as opposed to mission specialists who are career NASA astronauts and are trained on a diversity of experiments for a particular mission).

In 1984, Charles Walker became the first "industrial" astronaut. He is an employee of the McDonnell Douglas Corporation who specializes in continuous flow electrophoresis, a process for manfucturing very pure pharmaceuticals in space. Other payload specialists included an oceano-

grapher from the U.S. Navy (Paul Scully-Power), and a Navy commander from Canada (Marc Garneau) who performed a variety of optical experiments.

• Shuttle Problems. Despite the successes of the shuttle during 1984, the system continued to experience problems and delays. The most time consuming delay was related to computer and main engine malfunctions with the orbiter Discovery when it attempted to make its maiden voyage in June 1984. The launch was accomplished on the fourth try (two months later), and one attempt was scrubbed only four seconds before liftoff.

In November, an unexpected difficulty developed with the orbiter Challenger when it was discovered that thousands of thermal protection tiles had loosened and would have to be replaced. The problem was traced to a substance called "screed" which is similar to a spackling compound used to smooth over the surface of the orbiter before applying the tiles. NASA has determined that the screed softened because of a chemical interaction with the compound that had been used for waterproofing the tiles. Although the problem has been diagnosed and is being cured, Challenger had to be temporarily taken out of service and its payload shifted to Discovery, the only orbiter currently operational (Columbia, the first orbiter, is undergoing modifications to make it lighter weight). This delayed the scheduled December launch for the Department of Defense until January 1985.

B. SPACE SCIENCE AND APPLICATIONS

1. Soviet Union

• Spacecraft to Venus and Halley's Comet. The Soviets did not launch any earth orbital space science missions in 1984 (the launch of another side-looking radar for oceanographic studies is more applications than science), but did send two identical spacecraft to visit first Venus

and then Halley's Comet. Called VEGA 1 and 2, the spacecraft were launched in December 1984 and are expected to reach Venus in June 1985 where landers and balloons will be dropped off for scientific studies, while the spacecraft buses continue on to an intercept of Halley's Comet in March 1986. VEGA 1 will be the first of five spacecraft (two Soviet, two Japanese, and one European) to reach the comet in spring 1986. Eight other countries are directly participating in the Soviet VEGA program: Austria, Bulgaria, Czechoslovakia, East Germany, France, Hungary, Poland, and West Germany. Several American scientists are participating through third parties such as West Germany and Hungary.

2. United States

• Earth Orbital Science. Although the United States did not launch any deep space probes in 1984, it did deploy one space science free-flyer from the shuttle: the Long Duration Exposure Facility (LDEF) which carries 57 science and technology experiments. LDEF will be retrieved by another shuttle mission in 1985.

In addition, three scientific satellites were launched together by one Delta launch vehicle. Called AMPTE (Active Magnetospheric Particle Tracer Explorers), one spacecraft was developed by the United States, one by West Germany, and one by Britain. Together they are studying the Earth's magnetosphere and its interaction with the solar wind.

• Remote Sensing. The United States launched the fifth and last Landsat satellite in 1985, while the controversy over turning the satellite system over to the private sector continued. Although legislation was enacted outlining how the transfer should take place, and the Department of Commerce selected a company through competitive bidding to take over

Landsat, a dispute between Commerce and the Office of Management and Budget over the $250 million subsidy the Government had agreed to give the company left the proposed transfer in doubt at the end of 1984.

C. MILITARY SPACE ACTIVITIES

1. Soviet Union

• Reconnaissance Missions. Three different types of Soviet space reconnaissance missions were newsworthy in 1984. First, the Soviets launched what appears to be a new generation photographic reconnaissance satellite with a significnatly longer lifetime than previous missions. Kosmos 1552 operated for 173 days, far surpassing the previous duration of 67 days set by Kosmos 1426 in 1982-3. This new type of satellite may signal a transition to digital transmission satellites in the Soviet program.

The launch of Kosmos 1603 in September 1984 gave rise to considerable speculation in the West, and in its January 14, 1985 edition, Aviation Week and Space Technology reported that the spacecraft was a new, heavier electronic intelligence (ferret) reconnaissance satellite. The extensive orbital maneuvers which were used to place the satellite in its final orbit led some Western observers to speculate that either a new launch vehicle or at least a new upper stage was used, but it now appears that a standard Proton vehicle launched the spacecraft.

Finally, launches resumed of the nuclear-reactor powered radar ocean reconnaissance (RORSAT) spacecraft. Two launches were made, the first of which took place in June, 18 months after the failure of Kosmos 1402 in January 1983.

• Space Weapons. The Soviets did not conduct any tests of its ASAT device in 1984, consistent with the self-imposed "unilateral" moratorium

announced by then Soviet President Andropov in August 1983. In June 1984, the Soviets called upon the United States to negotiate a ban on space weapons, but after many weeks of charges and countercharges about each side setting unacceptable preconditions, no talks were scheduled. At the end of 1984, it was expected that a January 1985 meeting between U.S. Secretary of State Schultz and Soviet Foreign Minister Gromyko would lead to arms control negotiations which would include weapons in space.

2. United States

- Space Weapons. The United States reportedly conducted two tests of its F-15 antisatellite (ASAT) system in 1984. The tests were against points in space, rather than objects, and Congress prohibited testing against objects in space until March 1, 1985 or until 15 days after the President submits certain certifications to Congress concerning the tests, whichever is later (P.L. 98-473). The certifications which the President must give Congress include: that he is endeavoring in good faith to negotiate a mutual and verifiable agreement with the strictest possible limits on ASATS; that such tests would not gravely impair the prospects for reaching such an agreement; and that the tests would be consistent with the 1972 ABM Treaty. Furthermore, no more than three tests against objects in space are permitted in fiscal year 1985. Of the two "point" tests in 1984, DOD announced that the first (in January) was successful, although no statement was made regarding the success or failure of the second (in November).

The debate over space weapons intensified during 1984 as Congress deliberated over the merits of funding President Reagan's Strategic Defense Initiative (SDI) for performing research on a ballistic missile defense (BMD) system which might include space-based components, and over the need

for a U.S. ASAT system.

• DOD Participation in the Shuttle Program. A storm of controversy erupted over a December 1984 press conference at which DOD announced the rules it had established with regard to press coverage of its first dedicated space shuttle launch in January 1985. DOD does not announce the time of its launches or the payloads being carried, and since from DOD's perspective this was just another of its launches, it refused to release that information for the shuttle launch. The American public and the media, accustomed to NASA's openness about shuttle launches and payloads, generally reacted negatively to DOD's policy. On December 19, the Washington Post published a story stating that the payload was a signal intelligence satellite, prompting Secretary of Defense Weinberger to accuse the Post of "journalistic irresponsibility." The controversy continued at the end of 1984.

D. CHINA, EUROPE, INDIA, AND JAPAN

China launched three satellites, two of which came from a new launch site in Chengdu province in the southeastern part of the country (the exact location was not revealed). Both apparently employed the new Long March 3 (or CZ 3) launch vehicle which has a cryogenic liquid hydrogen/liquid oxygen upper stage. The second launch placed the first Chinese communications satellite in geostationary orbit, a significant achievement. There is some dispute in the West as to whether the first launch was a success or failure. Some think it was supposed to have placed a satellite in geostationary orbit and failed in that attempt, remaining in low earth orbit. Others think it was simply an engineering test of the new upper stage and was not intended to go into a higher orbit. The third launch came from the older facility at Shuang Cheng-tzu and was recovered, suggesting

a military reconnaissance role. The Chinese also announced that previously they had flown a puppy in space, although this was most likely a suborbital flight.

Four successful launches were made of the European Ariane launch vehicle, and operations were transferred from the European Space Agency (ESA) to a private company, Arianespace. ESA has stated it will continue to develop advanced versions of the launch vehicle, while Arianespace handles launch operations and marketing.

Japan launched three satellites: one scientific, one communications, and one meteorological. India made no launches in 1984.

E. SUMMARY OF SPACE LAUNCH AND PAYLOAD ACTIVITY IN 1984

The following list summarizes space launch and payload activity in 1984 for all the launching countries. A launch success means the payload reached orbit, whether or not it was the correct orbit, a payload success means that it was placed in the proper orbit and functioned.

COUNTRY	LAUNCH SUCCESSES	LAUNCH FAILURES	TOTAL LAUNCHES	PAYLOAD SUCCESSES	PAYLOAD FAILURES	TOTAL PAYLOADS
China	3	0	3	2	1	3
ESA	4	0	4	6	0	6
India	0	0	0	0	0	0
Japan	3	0	3	3	0	3
U.S.	22	0	22	34	3	37
U.S.S.R.*	97	0	97	114	1	115
TOTAL	129	0	129	159	5	164

* Payload count does not include orbital platforms (a type of upper stage)

F. PROSPECTUS FOR 1985

Making predictions about the future is always difficult, particularly in the case of the Soviet Union and China where space activities are conducted in secret. Nevertheless, it may be useful to speculate about what may develop in 1985, although these "predictions" should not be considered definitive.

1. Soviet Union

- New Launch Vehicles. Rumors about the "imminent" testing of two new launch vehicles, one similar to the U.S. Titan III and the other equivalent to the former U.S. Saturn V, raged throughout 1984 although no apparent tests were conducted. Such tests may occur in 1985.

- Spaceplane and Space Shuttle. Having completed four orbital tests of the sub-scale spaceplane, it would not be surprising if the Soviets moved on to an improved prototype (perhaps a full-scale model which can land on a runway) although this is extremely difficult to assess since the test results from the four flights have not been made public. There also are rumors that drop tests of the larger shuttle-class vehicle from an airplane might occur in 1985.

- Rotation of Space Station Crews. At international meetings in 1984, Soviet scientists indicated that the problem with having a permanent presence in space is not with space systems or space crews, but the need to maintain ground crews on duty for 24 hours a day throughout the mission, especially on the tracking ships. Thus, it may be that they will not attempt to occupy a space station permanently until they have rectified this problem (perhaps by launching a data relay satellite system so that the tracking ships are no longer needed), but this does not necessarily mean that they will not try rotating crews for shorter periods.

2. United States

The first 1985 shuttle flight is the first dedicated DOD flight and the controversy over the secrecy surrounding this mission has already been discussed. Also planned for 1985 is the first flight of a U.S. Senator (Jake Garn of Utah) as a "space flight participant," another new category of astronaut who is not trained to participate in activities on the shuttle, but essentially flies as a passenger. NASA has plans to fly a high school teacher as a passenger in 1985 or 1986. A Frenchman, Patrick Baudry (who was backup for Jean-Loup Chretien on Soyuz T-6) is scheduled to fly on the same mission as Senator Garn. At least two flights of Spacelab are planned and the second and third NASA Tracking and Data Relay Satellites are expected to be deployed. The fourth orbiter, Atlantis, will be delivered to NASA in April, completing the approved procurement of four orbiters, and the debate over the need for a fifth orbiter may become more prominent.

3. Other Countries

There are strong rumors that the Chinese may launch a meteorological satellite soon, and this is a good possibility for 1985. Further flights to demonstrate reconnaissance techniques might also be expected.

Arianespace has six (possibly seven) launches scheduled for 1985, including a European mission to study Halley's comet (Giotto), and a French remote sensing satellite, SPOT. A second launch pad at Kourou is scheduled to enter service in 1985, accommodating the higher launch rate.

Japan plans to launch two spacecraft (Sakigake and Planet-A) to study Halley's Comet. India's plans are not known.

INTRODUCTION

During the first era of the space program, only the United States and the Soviet Union had the ability to place satellites in Earth orbit or send them off to distant planets. As early as 1965, this monopoly was challenged by France, but the launch vehicle it developed could only orbit very small payloads, and its use ended ten years later. Britain also developed its own launch vehicle, but it was used only twice. Both Britain and France later joined with nine other European countries to form the European Space Agency, which now has a launch vehicle called Ariane. Three other countries -- China, India, and Japan -- also have independent launch capabilities.

The purpose of this report is to summarize the programs of the United States, Soviet Union, and the other "launching" countries. Not included are efforts by private groups in the United States and abroad (such as OTRAG and Space Services, Inc.) that are attempting to develop their own orbital launch capabilities; if they succeed, these programs will be included in future editions of this report.

As shown in table 1, the countries of the world have made 2,642 successful launches of 3,627 payloads since 1957. In addition, there were 131 announced launch failures, and another 192 possible launch failures that were not announced by the Soviet Union and China. The United States and Soviet Union are responsible for 98 percent of the payloads successfully placed in orbit; these are categorized by mission in table 2.

CRS has prepared several other reports on space which the reader may wish to consult for further information. A series of five-year studies on Soviet Space Programs has been prepared for the Senate Aeronautical and Space Sciences Committee (now part of the Senate Commerce, Science, and Transportation Committee) since the early 1960s. Volumes I and II of the most recent edition have been published; Volume III should be available early in 1985. United States Civilian Space Programs 1958-1978 (Volumes I and II) was written for and published by the House Science and Technology Committee in 1981 and 1983. A CRS Report on Military Space Activities should be available in the spring of 1985. World-Wide Space Activities, which provides detailed information on the space activities of all countries in the world except the United States and Soviet Union, was prepared for and published by the House Science and Technology Committee in 1977. CRS Report 84-127, Space Activities of the Non-Launching Countries updates information on countries which use space but do not have an indigenous launch capability.

Six CRS issue briefs are also available on space topics: "Star Wars": Antisatellites and Space-Based Ballistic Missile Defense, Issue Brief 81123; Space Policy and Funding: NASA and Civilian Space Programs, Issue Brief 82118; Space Policy and Funding: Military Uses of Space, Issue Brief 82117; Space Shuttle, Issue Brief 81175; and Space Stations and Space Commercialization, Issue Brief 83147, all by Marcia S. Smith; and Landsat: Earth Resources Satellite System, Issue Brief 82066, by Patricia Humphlett.

This report has been revised and updated by Marcia S. Smith, Specialist in Aerospace and Telecommunications Systems in the Science Policy Research Division. Mr. Geoffrey Perry, M.B.E., head of the Kettering Group in England, provided some of the data for the tables and other information. The report is based on careful analysis of information contained in the

numerous, unclassified sources cited in the above committee prints, and on earlier editions of this report written by the late Charles S. Sheldon II, formerly a Senior Specialist in Space and Transportation at CRS. Detailed citations are omitted for the purpose of keeping this annual update brief. The most frequently used sources, however, are publications of the Foreign Broadcast Information Service (FBIS), the Joint Publication Research Service (JPRS) and trade publications such as Aviation Week and Space Technology and Aerospace Daily.

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TABLE 1a: WORLD-WIDE RECORD OF KNOWN SUCCESSFUL SPACE LAUNCHES

YEAR	USSR	US*	FRANCE	AUSTRALIA	CHINA	JAPAN	UK	ESA**	INDIA	(ITALY)*	TOTAL	YEAR
1957	2										2	1957
1958	1	5									6	1958
1959	3	10									13	1959
1960	3	16									19	1960
1961	6	29									35	1961
1962	20	52									72	1962
1963	17	38									55	1963
1964	30	57									87	1964
1965	48	63	1								112	1965
1966	44	73	1								118	1966
1967	66	58	2	1						(1)	127	1967
1968	74	45									119	1968
1969	70	40									110	1969
1970	81	29	2		1	1				(1)	114	1970
1971	83	32	1		1	2	1			(2)	120	1971
1972	74	31			1					(1)	106	1972
1973	86	23									109	1973
1974	81	24			1					(2)	106	1974
1975	89	28	3		3	2				(1)	125	1975
1976	99	26			2	1					128	1976
1977	98	24			2						124	1977
1978	88	32			1	3					124	1978
1979	87	16			2			1			106	1979
1980	89	13			2				1		105	1980
1981	98	18			1	3		2	1		123	1981
1982	101	18			1	1					121	1982
1983	98	22			1	3		2	1		127	1983
1984	97	22			3	3		4			129	1984
TOTAL	1,733	844*	10	1	14	27	1	9	3	(8)	2,642	

*Italy has made a total of eight launches from its San Marco platform off the coast of Kenya in the years indicated. Because all of these launches were made using U.S. Scout rockets, they are counted by NASA, and here, as part of the U.S. launch total.

**European Space Agency

TABLE 1b: WORLD-WIDE RECORD OF KNOWN SPACE LAUNCH FAILURES

YEAR	USSR*	US	FRANCE	AUSTRALIA	CHINA*	JAPAN	UK	ELDO*	ESA**	INDIA	TOTAL*	YEAR
1957	?	1									1	1957
1958	?	12									12	1958
1959	?	10									10	1959
1960	2+?	13									15	1960
1961	?	12									12	1961
1962	?	7									7	1962
1963	?	8									8	1963
1964	?	7									7	1964
1965	?	7									7	1965
1966	?	4				2					6	1966
1967	?	3				1					4	1967
1968	?	3						1			4	1968
1969	?	1			1	1		1			4	1969
1970	?	1			?	1		1			4	1970
1971	?	3	1		?			1			5	1971
1972	?	2			?						2	1972
1973	?	2	1		?						3	1973
1974	?	1			?						1	1974
1975	2+?	3			?						5	1975
1976	?	0			?	1					1	1976
1977	?	2			?						2	1977
1978	?	1			?						1	1978
1979	?	0			1+?				1	1	3	1979
1980	?	2			?						2	1980
1981	2+?	1			?						3	1981
1982	?	0			?				1		1	1982
1983	1+?	0			?						1	1983
1984	?	0			?						0	1984
TOTAL	7 (188?)*	106	2		2 (4?)*	6	1	4	2	1	131 (323?)*	

*The Soviet Union and China traditionally do not report launch failures. In the rare instances where failures have been admitted by those countries or reported in the Western literature, they are shown here; otherwise question marks are used. The TOTAL column for these two countries show launch failures which have been publicly identified plus a total in parentheses which has been estimated by applying the U.S. failure rate to their launch success rate on the assumption that all development programs encounter similar difficulties. The total for all countries for all years of (314?) include these estimates, while the total of 131 does not.

** ESA is the European Space Agency. ELDO was the European Launcher Development Organization which became part of ESA.

TABLE 1c: WORLD-WIDE RECORD OF PAYLOADS SUCCESSFULLY LAUNCHED

YEAR	USSR*	US#†	FRANCE	AUSTRALIA	CHINA	JAPAN	UK	ESA	INDIA	(ITALY)†	TOTAL	YEAR
1957	2											
1958	1	5									2	1957
1959	3	10									6	1958
1960	3	17									13	1959
1961	8	35									20	1960
1962	26	59									43	1961
1963	20	62									85	1962
1964	39	73									82	1963
1965	76	97	1								112	1964
1966	52	101	1								174	1965
1967	75	88	2	1							154	1966
1968	85	64								(1)	166	1967
1969	80	66	3								149	1968
1970	103	40	1		1	1					149	1969
1971	114	54			1	2	1			(1)	146	1970
1972	109	42				1				(2)	172	1971
1973	130	26								(1)	152	1972
1974	114	28				1					156	1973
1975	140	35	4		3	2				(2)	143	1974
1976	141	34			2	1				(1)	184	1975
1977	125	29				2					178	1976
1978	142	41			1	3					156	1977
1979	126	18				1		1			187	1978
1980	132	16				1			1		146	1979
1981	125+23	20			3	3		5	1		150	1980
1982	119+22	20			1	1					180	1981
1983	116+22	30			1	3		3	1		163	1982
1984	114+24	34			2	3		6			176	1983
											183	1984
TOTAL	2,320+91	1,144	12	1	15	25	1	15	3	(8)	3,627	

* The Soviet Union uses launch platforms for placing satellites into highly elliptical, geostationary, and deep space orbits. This report has traditionally included the platform as a separate payload. Beginning in 1981, the Soviet totals are shown as two numbers: total number of payloads + total number of platforms. The yearly totals are shown in the same manner. This is to provide some consistency in the manner in which payloads are counted for each country, since upper stages (such as the inertial upper stage carried in the space shuttle cargo bay) are not counted separately for the United States.

FOOTNOTES FOR TABLE 1C (continued)

The space shuttle is counted as 1 payload, regardless of what it carries. Satellites deployed from the cargo bay are counted as additional payloads if they are left in orbit, even if they are retrieved on a later shuttle mission, such as the Long Duration Exposure Facility. Payloads deployed and retrieved on the same shuttle mission, such as SPAS-01 in 1983, are not counted as separate payloads. Upper stages such as IUS or PAM are not counted as separate payloads.

† Italy has launched a total of 8 payloads from its San Marco platform off the coast of Kenya in the years indicated. Because all of these launches were made using U.S. Scout rockets, they are counted by NASA, and here, as part of the U.S. total.

TABLE 2. Summary of U.S. and Soviet Payloads by Mission*

Category	United States 1984	United States 1957-1983	Soviet Union 1984	Soviet Union 1957-1983
Orbital launch platforms	--	--	24	270
Earth orbital science **	5	182	1	184
General engineering tests	0	28	0	2
Launch vehicle tests	0	11	0	16
Applications				
Communications	12	182	12	142
Weather	1	84	1	56
Geodesy	0	19	1	23
Earth resources	1	6	9	29
Man and biology related				
Earth orbit man-related	0	13	6	72
Earth orbit manned	5	29	3	59
Lunar man-related	0	17	0	8
Lunar manned	0	20	0	0
Deep space (other than man-related)				
Moon	0	25	0	34
Mercury	0	1	0	0
Venus	0	8	2	31
Mars	0	9	0	16
Outer planets	0	4	0	0
Interplanetary space	0	8	0	0
Military observation				
Low orbit recoverable (photo?)	3	238	27	585
Low orbit non-recoverable (elint?)	1	81	4	82
Minor military (calibration?)	0	43	4	136
High orbit (early warning?)	0	42	7	33
Ocean surveillance/elint	3	18	4	41
Navigation	3	42	15	86
Tactical and store/dump communications	0	0	18	312
Weapons-related				
Fractional orbit bombardment	0	0	0	18
Targets for anti-satellites	0	0	0	18
Anti-satellite interceptors	0	0	0	20
GRAND TOTAL	34	1,110	138	2,273

* Mission assignments are arbitrary to a degree, and are subject to revision each year as more information becomes available. Qualifying footnotes would fill many pages. Perhaps arbitrary assignments by category which may be either too high or too low sufficiently cancel out simplifications so that the totals for military and civil are generally indicative of divisions.

** Includes amateur radio satellites such as OSCAR, Radio, and Iskra 2 and 3.

PART ONE

U.S. AND U.S.S.R. SPACE ACTIVITIES

CHAPTER ONE: BRIEF HISTORY

In 1955 both the United States and the Soviet Union announced their intentions to launch small scientific satellites as a contribution to the International Geophysical Year, a world-wide scientific effort from July 1, 1957 to December 31, 1958 designed to increase understanding of Earth and space physics. President Eisenhower, wanting to demonstrate the U.S. commitment to using space for peaceful purposes, initiated Project Vanguard to develop a "civilian" rocket (i.e., not based on missile technology) and a satellite weighing 14 kilograms.

The general public, and many specialists who might have known better, were caught off guard when the 84 kilogram Sputnik 1 was placed in Earth orbit on October 4, 1957. Few had expected that the "backward" U.S.S.R. would beat the scientifically-advanced United States in this endeavor, and with a satellite many times heavier than what the United States was planning. Sputnik 2, launched on November 3, 1957, did not help the U.S. image: it weighed 508 kilograms, and carried a live dog, Layka. The first attempt to launch Vanguard, on December 6, 1957, ended in an embarrassing failure when it lifted three feet off the launch pad and came crashing back down in a fiery explosion. Eisenhower finally relented and allowed the Army to use its missile technology to place an Army satellite (Explorer 1) in orbit on January 31, 1958. Vanguard finally succeeded in placing a satellite in orbit on March 17, 1958.

CHAPTER TWO: MANNED SPACEFLIGHT

A. THE FIRST ERA: SHOOTING FOR THE MOON

1. Early Flights: 1961-1966

On April 12, 1961, Yuriy Gagarin became the first human being to travel in space as he made one orbit of the Earth in Vostok 1. On May 5, Alan Shepard became the first American in space, although his Mercury-Redstone 3 (Freedom 7) flight was suborbital, lasting for 15 minutes and landing about 480 kilometers downrange from Cape Canaveral.

Shepard's flight, even though it was suborbital, gave President Kennedy the confidence he needed to appear before Congress three weeks later, on May 25, 1961, to call upon the Nation to commit itself to the goal of landing a man on the Moon and returning him safely to Earth by the end of the decade. America accepted the challenge and the "Moon Race" was on, even though it was not until nine months later, on February 20, 1962, that John Glenn became the first U.S. astronaut to orbit the Earth.

The Vostok and Mercury flights were similar in purpose, and each country launched a total of six flights in their respective series (see Table 3). The flights demonstrated that humans could travel into space and return to Earth safely. The last of the Vostok flights took the first woman, Valentina Tereshkova, into space, where she remained for three days, gaining more time in orbit than all six U.S. Mercury astronauts combined.

The Soviet Union followed its Vostok series with two flights of a modified version of that spacecraft, called Voskhod. On October 1964,

Voskhod 1 carried the first three man crew, and in March 1965, the Voskhod 2 mission included the first extravehicular activity (EVA) or spacewalk. By contrast, the United States moved out quickly with the Gemini program in which 10 flights were conducted from 1965-1966 to increase the duration of the missions (up to 14 days), develop experience in rendezvous and docking procedures (skills which would be needed for the Apollo lunar landing program), and increase experience with EVAs (the first U.S. spacewalk occured in June 1965). While the United States conducted the Gemini flights, no Soviet manned flights were made, and skepticism developed as to whether the two countries were in a race to the Moon or not. Since the Soviet Union conducts its space program secretively, it was difficult to determine definitively what their plans were. One clue, however, were statements by leaders in the Soviet space program, including cosmonauts. On July 11, 1966, cosmonaut Vladimir Komarov stated that:

> There is no need to make haste about a Moon trip by human beings -- and the important thing is how to carry out everything in safety. But I can state positively that the Soviet Union will not be beaten by the United States in a race for a human being to go to the Moon.

2. 1967: Double Tragedies

In 1967, both countries were ready to introduce new manned space vehicles -- Apollo for the United States; Soyuz for the Soviet Union. The first flights of both of these vehicles ended in tragedy.

On January 27, 1967, the three man crew of what was to have been the first Apollo flight -- Gus Grissom, Ed White, and Roger Chaffee -- were killed when a fire erupted in their Apollo spacecraft during pre-launch tests. Three months later, on April 24, 1967, Vladimir Komarov, who has spoken so confidently of the Soviet Union being first on the Moon just

nine months earlier, was killed in the first Soyuz flight. The parachute lines in the final phase of recovery became twisted, and he was killed upon impact with the Earth. Both manned programs were set back for a year and a half.

3. The United States Wins the Moon Race

When the manned programs resumed in October 1968, it was clear that the United States was ahead in the Moon race. The first U.S. flight (Apollo 7) was a full scale test of the Apollo command module in Earth orbit. The first Soviet flight (Soyuz 2 and 3) was a simple rendezvous between a manned and an unmanned spacecraft, something that had been accomplished repeatedly in the U.S. Gemini program. In December 1968, three U.S. astronauts -- Frank Borman, Jim Lovell, and Bill Anders -- spent Christmas in lunar orbit. Their flight had been made possible by development of a special launch vehicle, the Saturn V, which was used to launch all the Apollo lunar missions. The Soviet Union was reported to be developing a launch vehicle with equivalent thrust, but the vehicle never achieved orbit (there are rumors that three test launches resulted in spectacular explosions), and as of the end of 1984, the Soviets still had never developed a launch vehicle similar to the Saturn V (see Chapter VI).

On July 20, 1969, the United States officially won the Moon Race when Neil Armstrong and "Buzz" Aldrin became the first humans to set foot on the lunar surface, while Mike Collins orbited overhead. Through 1972, five more U.S. crews set foot on the lunar surface (Apollo 12, 14, 15, 16 and 17) returning 380 kilograms of lunar material to Earth for analysis. A sixth attempt, Apollo 13 in 1970, narrowly averted tragedy when the crew safely returned to Earth after an explosion in the service module crippled some systems and cut consumable supplies. The lunar excursion module, designed

for supporting two men on the lunar surface, was used as a lifeboat to support all three crewmembers until they could return home after circumnavigating the Moon.

Meanwhile, the Soviet Union continued a few unmanned flights to develop hardware for a manned lunar mission (Zond 4-8 from 1968 to 1970, and apparently four Kosmos flights in 1970-1971), but lacking a launch vehicle with sufficient capability, they were unable to send people to the Moon and still have not done so, although they have retrieved lunar samples with automated probes (see Chapter IV).

Instead, they turned their attention to Earth orbit. In January 1969 they had accomplished the first docking of two manned ships (Soyuz 4 and 5) permitting crew transfer using EVA. Soyuz 6, 7, and 8 in October 1969 made a group coorbital flight, although it is thought that two of the ships (Soyuz 7 and 8) were supposed to dock, but were unable to do so. In 1970, Soyuz 9 set what was then a duration record of 18 days.

B. DETENTE IN SPACE: THE APOLLO-SOYUZ TEST PROJECT (ASTP)

As a contribution toward detente, and as a spur to the development of a universal, androgynous docking system which would purportedly allow each country to rescue the other's astronauts, the United States and Soviet Union agreed to work cooperatively to conduct a joint flight, called the Apollo-Soyuz Test Project (ASTP), in which a three-man Apollo crew would dock with a two-man Soyuz crew.

The Soviet Union agreed to a few modifications of the Soyuz spacecraft to permit this docking, and a test flight (Soyuz 16) was conducted in 1974. Both countries launched their ASTP spacecraft on July 15, 1975; the Soviet flight was designated Soyuz 19, while the U.S. flight has always been

referred to simply as ASTP. The two ships docked on July 17, and undocked on July 19 after two days of exchange visits and joint experiments. Soyuz 19 returned to Earth on July 21; ASTP landed on July 24.

ASTP was challenged in the United States on the grounds of cost, safety, and technology transfer. Since this was to be the last flight of the Apollo spacecraft, it was clear that the docking adapter would be useless as soon as the mission ended. Although scientific experiments were conducted, some questioned the cost investment for what was essentially a political mission, and there was concern that the United States was giving away more technology than it was gaining.

The Soviet investment in test flights and back-up hardware was probably at least as great as the U.S. investment in the docking module (which it supplied). Most of the safety charges lodged against the Soviets were based upon launcher problems (a manned mission in April 1975 suffered a third-stage malfunction and was aborted before reaching orbit), but the U.S. astronauts would not be riding on the Soviet launch vehicle, so this was not considered a safety problem from NASA's point of view.

Both sides were rather careful not to give away really private technology. The Soviets surely gained first hand insights into NASA management methods and documentation during visits to U.S. space facilities, but the Americans also were able to visit Soviet facilities and meet people in the Soviet space program never before accessible.

C. FIRST-GENERATION SPACE STATIONS

1. Salyut 1-5

The world's first space station, Salyut 1, was placed in orbit on April 19, 1971. When docked with a Soyuz, it had about 100 cubic meters of

interior space, compared to 275 cubic meters in the American Skylab space station (without the Apollo spacecraft).

Soyuz 10 was launched with a crew of three which docked with Salyut, but for reasons that were never explained, they were unable to enter the station, so returned to Earth after two days in orbit. Soyuz 11 successfully docked with the station, and the three man crew remained on board for 24 days conducting medical, Earth resources, and astronomical experiments. At the end of the mission, the Soviets encountered a second space tragedy when the crew returned to Earth on June 29, 1971. They had improperly closed a valve between two sections of the Soyuz spacecraft, and when the sections separated during reentry, the spacecraft's atmosphere vented into space. The Soviets had long since given up the practice of requiring crews to wear spacesuits because of confidence in their hardware, so the three men were asphyxiated. Since this flight, all Soviet cosmonauts have been required to wear spacesuits during launch and reentry, and because the original Soyuz was unable to accommodate three space-suited crewmembers, the Soviets launched only two-man crews for the next ten years until the redesigned Soyuz T came into use.

The next two space station launches, Salyut 2 and Kosmos 557 in 1973, were failures. They were followed by two free-flying Soyuz missions (Soyuz 12, a diagnostic flight following the Soyuz 11 tragedy, and Soyuz 13, a manned astronomical observatory).

Finally, in June 1974, the Soviets successfully orbited the next space station, Salyut 3. Western observers immediately noticed some interesting differences from Salyut 1: the crews sent to the station were all military instead of mixed military and civilian, when the crew entered the space station they switched to military telemetry, the orbit was lower

-- perhaps to improve picture resolution, and after it was unoccupied for a month, a data capsule was separated and returned to Earth in a manner similar to the return of photographic reconnaissance film. Therefore, this is counted in the West as the first military space station, optimized for reconnaissance activities. The Soviets stated that it was for Earth resources investigations. Of the two crews sent to Salyut 3, only one (Soyuz 14) was able to dock with it.

Salyut 4, launched December 26, 1974, was similar to Salyut 1 and so is counted as a civilian mission. Two crews docked with it (Soyuz 17 for 30 days and Soyuz 18 for 63 days), although a third (called the April 5th Anomaly or Soyuz 18A) was supposed to dock. In that case, a problem in the launch vehicle resulted in an abort which brought the crew back to Earth (unharmed) before reaching orbit. In November 1975, the unmanned Soyuz 20 docked with the station for a 90-day powered down test of the Soyuz spacecraft (although biological specimens were carried for scientific experiments).

The next station, Salyut 5, was similar to Salyut 3, suggesting the Soviets had an alternating program of military and civilian space stations during this period, and that had it been successful, Salyut 2 would have been the first military space station. Two crews successfully occupied Salyut 5 (Soyuz 21 for 46 days, Soyuz 24 for 18 days), while a third (Soyuz 23) was unable to dock.

Between the first two missions to Salyut 5, the Soviets launched another free-flying mission, Soyuz 22, which tested an East German-built multispectral camera (the MKF-6) for Earth resources studies. A modified version of the camera (MKF-6M) was installed on Salyut 6 and 7.

2. Skylab

On May 14, 1983, the United States orbited a space station developed from a Saturn IV-B stage called Skylab. The space station suffered considerable damage when its micrometeoroid shield and one of the main solar panels were ripped off during launch, but the first crew to visit the station effected repairs, and ultimately three crews docked with Skylab, for 28, 59, and 84 days respectively. A wide range of experiments were conducted in solar observations, Earth resources observations, biomedical research, and materials processing. The last crew left the space station in February 1974, and in July 1979 the station reentered the Earth's atmosphere, raining debris over parts of Western Australia and the Indian Ocean.

D. SECOND GENERATION SPACE STATIONS

1. Salyut 6

On September 29, 1977, the Soviets launched a second-generation space station called Salyut 6. The most important improvement in the station was the addition of a second docking port at the aft end of the station which enabled resupply flights to dock with the station while a crew was on board. Flights of a new unmanned cargo ship, called Progress, began in 1978, and the first in-space fuel transfer took place between Progress 1 and Salyut 6 in January of that year. Progress is a modified Soyuz spacecraft which is not designed to survive reentry. The second docking port was also used to enable additional crews to occupy the station as visitors to the long-duration crew. This provided opportunities for taking supplies to the orbiting crew, and for bringing the results of the various experiments conducted on board back to Earth (which would otherwise have to wait until the main crew returned).

During its four and a half years in orbit, Salyut 6 hosted 16 crews (2 other manned missions were unable to dock) which conducted a wide variety of Earth resources, materials processing, biomedical, and biological experiments (such as plant growth). The station was occupied for approximately 50 percent of the time it was in orbit. A total of 12 Progress flights resupplied the crews, and three other unmanned missions (Soyuz 34, Soyuz T, and Kosmos 1267) docked with the station. These missions are highlighted below.

On October 9, 1977, Soyuz 25 carried a crew up to enter the station, but a hard docking was not achieved and the crew returned to Earth after two days. In December 1977, the Soyuz 26 crew successfully docked at the opposite end of the station, and inspected the forward docking port during an EVA. They determined that it was fine, and thus began a full flowering of the Soviet Salyut space station program.

The Soyuz 26 crew set a world duration record of 96 days, sharing the station for a time with the crew of Soyuz 27, and received fresh supplies of consumables and instruments in Progress 1. Using Progress 1, the first in-space refueling of the space station was accomplished. The crew of Soyuz 28, which included the first Czechoslovakian cosmonaut, also visited. The Soyuz 26 and 27 crews traded spacecraft, so that the long duration crew would have a relatively fresh Soyuz for the journey home.

Soyuz 29 was launched on June 15, 1978 and set another duration record -- 140 days. They had visits from the Soyuz 30 crew, which included the first Polish cosmonaut and the Soyuz 31 crew with an East German cosmonaut. The Soyuz 29 and 31 crews exchanged spacecraft. Resupply missions were made by Progress 2, 3 and 4.

Soyuz 32, launched on February 25, 1979, brought the third long-duration crew to Salyut 6. They were to be visited by the crew of Soyuz 33, which

included a Bulgarian cosmonaut, but the ship could not dock because of an engine failure. Soyuz 34 was sent up unmanned to replace the aging Soyuz 32, later returning the crew to Earth after a record stay of 175 days. The station was replenished by Progress 5, 6, and 7. At the end of the year, a new class of ferry craft with enhanced capabilities, named Soyuz-T, docked with the station as part of an unmanned exercise which lasted over 100 days.

During 1980, Progress 8 made an automated resupply flight to the unmanned station, followed by the manned Soyuz 35 with a crew that stayed up for 185 days, which was not a new record since according to international standards, a new record must exceed the old record by 10 percent. The long-duration team was visited by the Soyuz 36 crew, which included a Hungarian, and they traded spacecraft. Soyuz T-2 brought the next visiting Soviet crew up to the station in the first manned use of Soyuz T. Soyuz 37 carried up a visiting crew which included a Vietnamese, trading ships again to return to Earth in Soyuz 36. Soyuz 38 brought a visiting crew which included a Cuban. On October 11, the long-duration crew, originally launched in Soyuz 35, came home in Soyuz 37. In November, Soyuz T-3 carried a three-man crew to the station on a 13-day flight, the first crew of that size since the ill-fated flight of Soyuz 11 back in 1971. During the year, three Progress flights (9, 10, and 11) resupplied the station.

Three more manned flights to Salyut 6 were accomplished during 1981. The Soyuz T-4 crew remained on-board for 75 days, and was visited by the crews of Soyuz 39 and Soyuz 40. These last two missions also completed the program of launching representatives of the Interkosmos countries, with Mongolian and Romanian cosmonauts respectively. The station was also resupplied by Progress 12 in 1981. The Soviets announced that Soyuz 40 was

the last flight of the Soyuz spacecraft, which had been in service since 1967, and they would rely instead on the modified Soyuz T.

In June 1981, the unmanned spacecraft Kosmos 1267 docked with Salyut 6. The Soviets announced that its purpose was testing of a modular space station concept, and that Kosmos 1267 had life support systems on-board. Later, Aviation Week and Space Technology reported that Kosmos 1267 was in fact a "battle station" in orbit, armed with infrared homing devices. Salyut 6 and Kosmos 1267 were deorbited on July 29, 1982 while they were still docked. The full nature of Kosmos 1267's mission remains unclear, but probably was a modular space station test as the Soviets claimed.

2. Salyut 7

Salyut 7 was launched on April 19, 1982, the eleventh anniversary of the launch of Salyut 1. The space station is virtually identical to Salyut 6, although the Soviets report that it has an improved navigation system. The first crew, Soyuz T-5, was launched on May 13 and remained on board for 211 days, setting a new record. Two crews visited the long-duration crew: Soyuz T-6 which included the first French "spationaut" and Soyuz T-7 which included the second woman (Svetlana Savitsksya) to fly in space. There were four Progress resupply missions (13, 14, 15, and 16) in 1982.

In March 1983, the Soviets launched Kosmos 1443, which docked with Salyut 7 a week later. The Soviet press reported that this was an "operational" version of Kosmos 1267, and was a multipurpose vehicle which could be used as a cargo ship (with 2.5 times the capacity of Progress), a space tug, and/or a module to increase the habitable volume of the space station by 50 cubic meters. It also had a descent module for returning material to Earth.

The first attempt to occupy the Salyut 7/Kosmos 1443 complex was unsuccessful when the Soyuz T-8 crew was unable to dock. In June, the Soyuz T-9 crew achieved a successful docking, and, once aboard, began unloading Kosmos 1443. Afterwards, Kosmos 1443 was separated from Salyut, and the descent module returned to Earth while the main part burned up in the atmosphere. On September 26, the Soviets attempted to launch the Soyuz T-10 crew, but a fire developed in the launch vehicle and the crew was jettisoned from the launch pad using the Soyuz emergency escape system, the first time this procedure has actually been used in either the U.S. or Soviet program. The two men (both of whom were also members of the failed T-8 crew) were rescued safely. It is generally thought that this crew would have replaced, rather than simply visited, the T-9 crew. Instead, the T-9 crew remained on board, and on November 1 and 3 conducted EVAs to install additional solar panels on the space station by attaching them to the existing arrays. The T-9 crew returned in November 1983, after remaining in space for 149 days. In addition to Kosmos 1443, two Progress missions (17 and 18) resupplied the station.

During 1984, Salyut 7 was occupied by another long duration crew, Soyuz T-10, which set a new record of 237 days. This three-man crew included a cardiologist, who became the second physician cosmonaut. They were visited by two other crews, the first of which (Soyuz T-11) included the first Indian cosmonaut, while the second (Soyuz T-11) included Svetlana Savistskaya who became the first woman to fly into space twice, and the first woman to perform a spacewalk. She and another Soyuz T-12 crewmember spent more than three hours testing new equipment for soldering, welding, and spraying coatings in space. The long duration crew spent most of its time performing operations related to the visiting crews, the docking of

five Progress missions (Progress 19, 20, 21, 22, and 23), and six spacewalks. Five of the six spacewalks, which were conducted by two of the three men, were required to repair a leak in a fuel valve which had occurred in 1983; the sixth was needed to attach another set of new solar panels to one of the existing main arrays. During these six EVAs, the two men accumulated more time on EVA (22 hours 50 minutes) than the most on a U.S. spaceflight (22 hours 25 minutes by the Skylab 4 crew).

E. REUSABLE SPACE VEHICLES

1. The U.S. Space Shuttle

In 1972, President Nixon approved development of a reusable manned spacecraft, called the space shuttle. At the end of 1984, it had made 14 successful flights, and was the only reusable space vehicle in the world. The space shuttle consists of a reusable orbital stage about the size of a DC-9, powered by three liquid hydrogen-liquid oxygen engines (called the main engines), a large "external tank" which holds the fuel for those engines and which is not recovered, and two solid rocket boosters attached to either side and which are recovered for refurbishment and reuse after they splash down in the ocean.

The shuttle is often described as a "space truck" for hauling people and cargo back and forth to space. Crew size varies according to a particular mission, but normally ranges from four to seven: a commander, a pilot, and a mixture of mission specialists (career astronauts generally familiar with all the experiments and payloads being carried), payload specialists (non-career astronauts intimately familiar with one particular experiment or payload), and passengers (non-career astronauts who are taken along to experience spaceflight first hand).

The first space shuttle flight was successfully accomplished on April 12, 1981, and was followed by three more orbital test flights (one in 1981, two in 1982). The first operational launch of the shuttle took place on November 11, 1982, and was used to place two communications satellites into geostationary orbit. This was also the first time a four-man crew was launched.

During 1983, four shuttle missions were launched, the first time in ten years that the number of U.S. manned flights exceeded those of the Soviets. The first for the year, STS-6, placed one of NASA's new Tracking and Data Relay Satellites (TDRS) in space, although the upper stage failed and placed TDRS into an improper orbit. Using the spacecraft's stationkeeping thrusters, ground controllers were able to nudge it into a usable orbit over a period of several months. STS-7 took the first U.S. woman in space, and the crew deployed two communications satellites (one for Indonesia, one for Canada). This was the first five-person crew. STS-8 included the first U.S. black to go into space, and the crew deployed a communications satellite for India. STS-9 was the first flight of the European-built Spacelab, which flies in the cargo bay of the orbiter. This was the first six-person crew and included the first non-American to fly on an American manned mission (a West German). More than 70 experiments were conducted on the Spacelab 1 mission over a ten day period of time.

Five shuttle missions were successfully accomplished in 1984, half the number NASA had planned. The first flight of the year initiated a new numbering system for shuttle flights, and was designed STS 41-B. Theoretically, the numbering system shows the fiscal year in which the launch took place (4 representing FY1984), the launch site (1 for Cape Canaveral, 2 for Vandenberg Air Force Base which will become available for shuttle launches in January 1986), and the order in which the flight occurred

(B representing the second flight of FY84). Continual changes in NASA's flight schedule has resulted in this system not being followed (for example, STS 41-G was the first flight of FY1985, while STS 51-A was the second flight of FY1985).

The activities of the shuttle crews during 1984, and the problems which were encountered with the shuttle system during the year, are explained in the "Highlights" section at the beginning of this report. Briefly, 1984 saw the first use of the Manned Maneuvering Unit which allows an astronaut to travel away from the shuttle without being tethered to it. Bruce McCandless tested the device on STS 41-B, and it was used operationally on two other shuttle flghts in 1984. Three satellites were retrieved by astronauts, one of which (the Solar Maximum Mission) was repaired and redeployed in orbit by the STS 41-C crew, while the other two were returned to Earth by the STS 51-A crew. On the STS 41-G mission, Kathryn Sullivan became the first American woman to perform a spacewalk, Sally Ride became the first American to fly into space twice, and the first in-space refueling was accomplished by a U.S. crew. Charlie Walker became the first "industrial" payload specialist, performing electrophoresis experiments for a joint McDonnell Douglas/Johnson and Johnson endeavor, and Marc Garneau became the first Canadian to fly in space.

2. Soviet Development of a Spaceplane and Shuttle

Speculation has existed for many years that the Soviet Union is developing a reusable space shuttle vehicle. During the late 1970s, there were unconfirmed reports that drop tests of a shuttle vehicle had been made from aircraft and that a space launch could be expected soon.

An operational launch has not yet taken place, although in 1982, an unusual Soviet satellite, Kosmos 1374, was rumored to have been a test of a scale-model of a reusable spacecraft. Kosmos 1374 made only one and a quarter orbits and landed in the Indian Ocean where it was recovered by a Soviet fleet. Another unusual aspect of the flight is that it was launched from the Kapustin Yar launch site which is ordinarily used for small scientific and international cooperative missions, but not for man-related development programs.

In March 1983, the U.S. Department of Defense released an update of its Soviet Military Power report which stated that the Soviets are developing two reusable shuttle vehicles: one similar to the U.S. shuttle, and a smaller "space plane." According to the DOD report, orbital test flights of the smaller vehicle had already occurred, a possible reference to Kosmos 1374.

A very similar mission was flown in March 1983, Kosmos 1445, and this time the Australians released several pictures of the vehicle as it was being recovered from the Indian Ocean by a Soviet ship. In December 1983, a third mission of this type of was flown, Kosmos 1517, only this time it made a "controlled descent" into the Black Sea, rather than the Indian Ocean. A similar flight occurred in December 1984 with Kosmos 1614. At the end of 1984, four flights of this sub-scale prototype, each completing slightly more than one orbit, had been made as follows:

DATE	SPACECRAFT	LAUNCH SITE	LANDING SITE
June 3, 1982	Kosmos 1374	Kapustin Yar	Indian Ocean
Mar. 15, 1983	Kosmos 1445	Kapustin Yar	Indian Ocean
Dec. 27, 1983	Kosmos 1517	Kapustin Yar	Black Sea
Dec. 19, 1984	Kosmos 1614	Kapustin Yar	Black Sea

TABLE 3a. Summary List of Manned Space Flights

Launch Date	Vehicle Name	Crew (no. of flights)	Weight (kgs)	Ship Duration (hr:min)	Crew Duration (hr:min)	Orbits	National Cumulative Personhours
1961							
Apr. 12	Vostok 1	Gagarin	4,725	1:48	same	1	1:48
May 5	MR-3	Shepard	1,290	:15	same	--	:15
July 21	MR-4	Grissom	1,286	:16	same	--	:31
Aug. 6	Vostok 2	G. Titov	4,731	25:18	same	17	27:06
1962							
Feb. 20	MA-6	Glenn	1,355	4:55	same	3	5:26
May 24	MA-7	Carpenter	1,349	4:56	same	3	10:22
Aug. 11	Vostok 3	Nikolayev	4,722	94:22	same	64	121:28
Aug. 12	Vostok 4	Popovich	4,728	70:57	same	48	192:25
Oct. 3	MA-8	Schirra	1,373	9:13	same	6	19:35
1963							
May 15	MA-9	Cooper	1,376	34:20	same	23	53:55
June 14	Vostok 5	Bykovskiy	4,720	119:06	same	81	311:31
June 16	Vostok 6	Tereshkova	4,713	70:50	same	48	382:21
1964							
Oct. 12	Voskhod 1	Komarov Yegorov Feoktistov	5,320	24:17	same	16	455:12
1965							
Mar. 18	Voskhod 2	Belyayev Leonov	5,682	26:02	same	17	507:16
Mar. 23	Gemini 3	Grissom (2) Young	3,225	4:53	same	3	63:41
June 3	Gemini 4	McDivitt White	3,574	97:56	same	66	259:33
Aug. 21	Gemini 5	Cooper (2) Conrad	3,605	190:55	same	128	641:23
Dec. 4	Gemini 6	Borman Lovell	3,663	330:35	same	220	1,302:33
Dec. 15	Gemini 7	Schirra (2) Stafford	3,546	25:51	same	17	1,354:15

TABLE 3a. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew (No. of flights)	Weight (kgs)	Ship Duration (hr:min)	Crew Duration (hr:min)	Orbits	National Cumulative Personhours
1966							
Mar. 16	Gemini 8	Armstrong Scott	3,788	10:41	same	7	1,375:37
June 3	Gemini 9	Stafford (2) Cernan	3,750	72:21	same	47	1,520:19
July 18	Gemini 10	Young (2) Collins	3,741	70:47	same	46	1,661:53
Sept. 12	Gemini 11	Conrad (2) Gordon	3,860	71:17	same	47	1,804:27
Nov. 11	Gemini 11	Lovell (2) Aldrin	3,763	94:35	same	63	1,993:37
1967							
Jan. 27	AS-204	Grissom (3)† White (2)† Chaffee†		[Not a space flight, but date of fatal fire on pad during test preliminary to later scheduled flight.]			
Apr. 23	Soyuz 1	Komarov (2)†	20,412 6,450	26:48	same	18	534:04
1968							
Oct. 11	Apollo 7	Schirra (3) Eisele Cunningham	20,569	260:09	same	174	2,774:04
Oct. 26	Soyuz 3	Beregovoy	6,575	94:51	same	64	628:55
Dec. 21	Apollo 8	Borman (2) Lovell (3) Anders	43,663	147:01	same	2(Earth) 10 (Moon)	3,215:07
1969							
Jan. 14	Soyuz 4	Shatalov (Yeliseyev) (Khrunov)	6,625	71:21	same	48	795:54
Jan. 15	Soyuz 5	Volynov Yeliseyev Khrunov	6,585	72:54	same for 1 47:49 for 2	49	868:48

† Fatality

TABLE 3a. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew (No. of flights)	Weight (kgs)	Ship Duration (hr:min)	Crew Duration (hr:min)	Orbits	National Cumulative Personhours
1969 (cont.)							
Mar. 3	Apollo 9	McDivitt (2) Scott (2) Schweickart	43,185	241:01	same	162	3,938:10
May 18	Apollo 10	Stafford (3) Young (3) Cernan (2)	48,638	192:03	same	2 (Earth) 31 (Moon)	4,514:19
July 16	Apollo 11	Armstrong (2) Collins (2) Aldrin (2)	49,698	195:19	same	2 (Earth) 30 (Moon)	5,100:16
Oct. 11	Soyuz 6	Shonin Kubasov	6,577	118:43	same	80	1,106:14
Oct. 12	Soyuz 7	Filipchenko Gorbatko Volkov	6,570	118:40	same	80	1,462:14
Oct. 13	Soyuz 8	Shatalov (2) Yeliseyev (2)	6,646	118:51	same	80	1,699:56
Nov. 14	Apollo 12	Conrad (3) Gordon (2) Bean	49,804	244:36	same	2 (Earth) 45 (Moon)	5,834:04
1970							
Apr. 11	Apollo 13	Lovell (4) Haise Swigert	49,990	142:55	same	2 (Earth) 1 (Moon)	6,262:49
June 1	Soyuz 9	Nikolayev (2) Sevastyanov	6,500	424:59	same	286	2,549:54
1971							
Jan. 31	Apollo 14	Shepard (2) Roosa Mitchell	46,347	216:02	same	2 (Earth) 34 (Moon)	6,910:55
Apr. 19	Salyut 1	(Occupied by Soyuz 11 crew)	18,600?	---		---	---

TABLE 3a. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew	Weight (kgs)	Ship Duration (hr:min)	Crew Duration (hr:min)	Orbits	National Cumulative Personhours
1971 (cont.)							
Apr. 22	Soyuz 10	Shatalov (3) Yeliseyev (3) Rukavishnikov	6,575?	47:46	same	32	2,693:12
June 6	Soyuz 11	Dobrovolskiy† Volkov (2)† Patsayev†	6,575?	570:22	same	385	4,404:18
July 26	Apollo 15	Scott (3) Irwin Worden	52,759	295:12	same	2 (Earth) 74 (Moon)	7,796:31
1972							
Apr. 16	Apollo 16	Young (4) Duke	51,571	265:51	same	2 (Earth) 65 (Moon)	8,594:04
Dec. 7	Apollo 17	Cernan (3) Schmitt Evans	51,808	301:52	same	3 (Earth) 75 (Moon)	9,499:40
1973							
May 14	Skylab 1	(Occupied by Skylab 2,3 & 4 crews)	89,439	---		---	---
May 25	Skylab 2	Conrad (4) Kerwin Weitz	30,803	672:50	same	433	11,518:10
July 28	Skylab 3	Bean (2) Garriott Lousma	30,694	1,427:09	same	919	15,799:37
Sept. 27	Soyuz 12	Lazarev Makarov	6,575?	47:16	same	32	4,498:50
Nov. 16	Skylab 4	Carr Gibson Pogue	31,232	2,017:16	same	1,298	21,851:25
Dec. 18	Soyuz 13	Klimuk Lebedev	6,575?	188:56	same	127	4,876:42

† Fatality

TABLE 3a. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew (No. of flights)	Weight (kgs)	Ship Duration (hr:min)	Crew Duration (hr:min)	Orbits	National Cumulative Personhours
1974							
June 24	Salyut 3	(Occupied by Soyuz 14 crew)	18,900?	---		---	---
July 3	Soyuz 14	Popovich (2) Artyukhin	6,570?	337:30	same	252	5,631:42
Aug. 26	Soyuz 15	Sarafanov Demin	6,570?	48:12	same	32	5,728:06
Dec. 2	Soyuz 16	Filipchenko (2) Rukavishnikov (2)	6,570?	142:24	same	96	6,012:54
Dec. 26	Salyut 4	(Occupied by Soyuz 17, 18 crews)	18,900	---		---	---
1975							
Jan. 10	Soyuz 17	Gubarev Grechko	6,570?	709:20	same	466	7,431:34
Apr. 5	Anomaly	Lazarev (2) Makarov (2)	6,570?	:20	same	---	7,432:14
May 24	Soyuz 18	Klimuk (2) Sevastyanov (2)	6,570?	1,511:20	same	993	10,454:54
July 15	Soyuz 19	Leonov (2) Kubasov (2)	6,800	142:31	same	96	10,739:56
July 15	ASTP	Stafford (4) Slayton Brand	14,743	217:28	same	145	22,503:49
1976							
June 22	Salyut 5	(Occupied by Soyuz 21, 24 crews)	18,900?	---		---	---
July 6	Soyuz 21	Volynov (2) Zholobov	6,570?	1,182:23	same	790	13,104:42
Sept. 15	Soyuz 22	Bykovskiy (2) Aksenov	6,570?	189:52	same	127	13,484:26
Oct. 14	Soyuz 23	Zudov Rozhdestvenskiy	6,570?	48:07	same	32	13,580:40

TABLE 3a. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew	Weight (kgs)	Ship Duration (hr:min)	Crew Duration (hr:min)	Orbits	National Cumulative Personhours
1977							
Feb. 7	Soyuz 24	Gorbatko (2) Glazkov	6,570?	425:26	same	285	14,431:32
Sept. 29	Salyut 6	(Occupied by Soyuz 26, 27, 28, 29, 30, 31, 32, 35, 36, 37, 38, T2, T3, T4, 39, 40 crews)	18,900?	---		---	---
Oct. 9	Soyuz 25	Kovalenok Ryumin	6,570?	48:45	same	32	14,529:02
Dec. 10	Soyuz 26	Romanenko Grechko (2)	6,570?	898:06	2314:00	590	19,157:02
1978							
Jan. 10	Soyuz 27	Dzhanibekov Makarov (3)	6,570?	1,558:53	142:59	1,024	19,443:00
Mar. 2	Soyuz 28	Gubarev (2) Remek (Czechoslovakia)	6,570?	190:16	same	125	19,823:32
Jun. 15	Soyuz 29	Kovalenok (2) Ivanchenkov	6,570?	1,911:23	3350:48	125	26,525:08
Jun. 27	Soyuz 30	Klimuk (3) Hermaszewski (Poland)	6,570?	190:03	same	125	26,905:14
Aug. 26	Soyuz 31	Bykovskiy (3) Jahn (German Dem. Rep.)	6,570?	1,628:14	188:49	1,070	27,282:52

TABLE 3a. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew	Weight (kgs)	Ship Duration (hr:min)	Crew Duration (hr:min)	Orbits	National Cumulative Personhours
1979							
Feb. 25	Soyuz 32	Lyakhov Ryumin (2) (Returned unmanned)	6,570?	2,596:24	4,200:36	1,711	35,684:04
Apr. 10	Soyuz 33	Rukavishnikov (3) Ivanov (Bulgaria)	6,570?	47:01	same	31	35,778:06
June 6	Soyuz 34	(Launched unmanned, returned Soyuz 32 crew)	6,570?	1,770:17	0	1,153	---
1980							
Apr. 9	Soyuz 35	Popov Ryumin (3)	6,570?	1,321:29	4,436:12	868	44,650:30
May 26	Soyuz 36	Kubasov (3) Farkas (Hungary)	6,570?	1,580:54	188:46	1,040	45,028:02
June 5	Soyuz T-2	Malyshev Aksenov (2)	7,000?	94:19	same	62	45,216:40
July 23	Soyuz 37	Gorbatko (3) Pham Tuan (Viet Nam)	6,570?	1,911:17	188:42	1,257	45,594:04
Sept. 18	Soyuz 38	Romanenko (2) Tamayo Mendez (Cuba)	6,570?	188:43	same	124	45,971:30
Nov. 27	Soyuz T-3	Kizim Makarov (4) Strekalov	7,000?	307:08	same	204	46,892:54

TABLE 3a. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew	Weight (kgs)	Ship Duration (hr:min)	Crew Duration (hr:min)	Orbits	National Cumulative Personhours
1981							
Mar. 12	Soyuz T-4	Kovalenok (3) Savinykh	7,000?	1,794:38	same	1,196	50,482:10
Mar. 22	Soyuz 39	Dzhanibekov (2) Gurragcha (Mongolia)	6,570?	188:43	same	125	50,859:36
Apr. 12	STS 1	Young (5) Crippen	98,658	54:21	same	36	22,612:31
May 14	Soyuz 40	Popov (2) Prunariu (Romania)	6,570?	188:41	same	126	51,236:58
Nov. 12	STS 2	Engle Truly	103,811	54:13	same	36	22,720:57
1982							
Mar. 22	STS 3	Lousma (2) Fullerton	106,000	192:05	same	128	23,105:07
Apr. 19	Salyut 7	(Occupied by Soyuz T-5, T-6, T-7,T-9,T-10, T-11, T-12 crews)	18,900?	--		--	--
May 13	Soyuz T-5	Berezovoy Lebedev (2)	7,000?	2,549:06	5,073:05	1,690	61,383:08
June 24	Soyuz T-6	Dzhanibekov (3) Ivanchenkov (2) Chretien (France)	7,000?	189:51	same	126	61,952:41
June 27	STS-4	Mattingly (2) Hartsfield	108,797	169:10	same	112	23,443:27
Aug. 19	Soyuz T-7	Popov (3) Serebrov Savitskaya	7,000?	2,712:51	189:52	1,800	62,522:17
Nov. 11	STS-5	Brand (2) Overmyer Allen Lenoir	111,201	122:14	same	82	23,932:23

TABLE 3a. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew	Weight (kgs)	Ship Duration (hr:min)	Crew Duration (hr:min)	Orbits	National Cumulative Personhours
1983							
Apr. 4	STS-6	Weitz (2) Bobko Musgrave Peterson	114,201	120:24	same	80	24,413:59
Apr. 20	Soyuz T-8	V. Titov Strekalov (2) Serebrov (2)	7,000?	48:18	same	32	62,667:11
June 18	STS-7	Crippen (2) Hauck Ride Fabian Thagard	110,013	146:24	same	98	25,145:59
June 27	Soyuz T-9	Lyakhov (2) Alexandrov	7,000?	3,585:46	same	2,391	69,838:43
Aug. 30	STS-8	Truly (2) Brandenstein Thornton Bluford D. Gardner	104,675	145:09	same	97	25,871:44
Sept. 26	(Soyuz T-10)	V. Titov (2) Strekalov (3)	(Not a spaceflight. Crew jettisoned using emergency abort system after fire erupted in launch vehicle prior to launch)				
Nov. 28	STS-9	Young (6) Shaw Parker Garriott (2) Lichtenberg Merbold (W. Germany)	110,031	247:47	same	165	27,358:26

TABLE 3a. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew	Weight (kgs)	Ship Duration (hr:min)	Crew Duration (hr:min)	Orbits	National Cumulative Personhours
1984							
Feb. 3	STS 41-B	Brand (3) R. Gibson McCandless McNair Stewart	113,508	191:16	same	127	28,314:46
Feb. 8	Soyuz T-10	Kizim (2) Solovyev Atkov	7,000?	1510:43	5686:50	1008	74,370:52
Apr. 3	Soyuz T-11	Malyshev (2) Strekalov (3) Sharma (India)	7,000?	4365:48	189:41	2914	87,468:16
Apr. 6	STS 41-C	Crippen (3) Scobee Hart van Hoften Nelson	115,342	167:40	same	112	29,153:06
July 17	Soyuz T-12	Dzhanibekov (4) Savitskaya (2) Volk	7,000?	283:14	same	189	88,317:58
Aug. 30	STS 41-D	Hartsfield (2) Coats Resnik Hawley Mullane C. Walker	119,491	144:57	same	97	30,022:48

TABLE 3a. Summary List of Manned Space Flights--continued

Launch Date	Vehicle Name	Crew	Weight (kgs)	Ship Duration (hr:min)	Crew Duration (hr:min)	Orbits	National Cumulative Personhours
1984 (cont)							
Oct. 5	STS 41-G	Crippen (4) McBride Ride (2) Sullivan Leestma Scully-Power Garneau (Canada)	110,109	197:24	same	132	31,404:36
Nov. 8	STS 51-A	Hauck (2) D. Walker Allen (2) A. Fisher D. Gardner (2)	119,421	191:45	same	128	32,363:21

TABLE 3b. NUMBER OF INDIVIDUALS WHO HAVE FLOWN IN SPACE

COUNTRY	TOTAL INDIVIDUALS WHO HAVE FLOWN IN SPACE: 1961-1984
UNITED STATES	84
SOVIET UNION	58
BULGARIA*	1
CANADA †	1
CZECHOSLOVAKIA*	1
CUBA*	1
FRANCE*	1
GERMAN DEMOCRATIC REPUBLIC*	1
GERMANY, FEDERAL REPUBLIC OF †	1
HUNGARY*	1
INDIA*	1
MONGOLIA*	1
POLAND*	1
ROMANIA*	1
VIETNAM*	1
TOTAL	155

* Flew on Soviet spaceflight

† Flew on U.S. spaceflight

CHAPTER THREE: SPACE APPLICATION FLIGHTS

Applications satellites are those spacecraft whose functions provide direct applications to the user, and include communications, navigation, remote sensing of the Earth's surface, weather, and geodesy. While the term is usually applied to civilian satellites, they are close cousins of military satellites, and in most cases it is extremely difficult to distinguish whether a particular satellite should be counted as military or civilian. Military space activities in general are discussed in Chapter V.

A. COMMUNICATIONS

The United States was the first country to experiment with communication satellites. At first, satellites which could store information for later relay to Earth (sometimes referred to as store/dump) were used (such as Score) and at about the same time, passive balloon reflectors (Echo, for example). Beginning in 1963, the United States began placing communications satellites in geostationary orbit at 35,880 kilometers altitude above the Equator. A satellite in this orbit will maintain a fixed postition relative to the ground. Color TV, telephone calls, and data can be relayed across oceans, and as capacity has grown, the costs of operation have diminished. At the initiative of the United States, the International Telecommunications Satellite Organization (INTELSAT) was established in 1964 to provide for an international communication satellite system. By the end of 1984, 109 countries were members of INTELSAT.

The Soviet Union has a different approach to communications satellites, and established the first domestic communications satellite system beginning in 1965. These Molniya satellites are in highly elliptical orbits with an apogee of approximately 40,000 kilometers over the northern hemisphere and a perigee of approximately 500 kilometers over the southern hemisphere, rather than in geostationary orbit. This provides a long linger time over the northern hemisphere (8 hours), and a system of these satellites can provide 24 hour coverage. The Molniya type of orbit is better for communicating at high latitudes where the curvature of the Earth makes it difficult for signals to reach from the Equator.

Although the Molniya orbit is good for internal communications in the Soviet Union, geostationary satellites are useful for international communications. In 1974 the Soviets placed their first geostationary satellite in orbit. Since then, they have developed three different geostationary satellite systems: Raduga (1975), Ekran (1976), and Gorizont (1978). Two geostationary satellites with experimental systems were launched in 1982: Gorizont 5, which in addition to its regular transponders in the 6/4 GHz band, carried new Luch transponders which operate in the 14/11 GHz range, and Volna transponders for maritime use; and Kosmos 1366 which the Soviets reported was performing tests in the SHF range. A satellite which may be similar to Kosmos 1366 was launched in 1984 (Kosmos 1543). The Soviets have also filed a notice with the International Telecommunication Union for a satellite system called GALS which is thought to be for military communications, although none of this series has been launched yet.

The Soviet Union uses the INTELSAT system, but is not a member of it. Instead, it formed INTERSPUTNIK in 1971 as a competitor to INTELSAT. At the end of 1984, 14 countries were members of INTERSPUTNIK.

The Soviets launch satellites under the Kosmos name which apparently use store/dump techniques for theater/tactical use.

Communications satellites are also very useful for maritime purposes, and in 1979 the International Maritime Satellite Organization (INMARSAT) was formed. Both the United States and Soviet Union belong to INMARSAT, along with 33 other countries.

B. METEOROLOGICAL SATELLITES

The United States has an operational weather satellite system using two satellites in Sun-synchronous polar orbits (called NOAA for the National Oceanic and Atmospheric Administration which operates them), and two Geostationary Operational Environmental Satellites (GOES) in geostationary orbit. (Each time a satellite in a Sun-synchronous orbit passes over any given location on Earth, it is precisly the same time as when it last passed over that site, e.g. 9:30 a.m., thus providing data with the same Sun angles which makes analysis of the data much easier.) NASA developed a low-cost ground terminal for receiving data from the polar orbiting satellites, called APT (automatic picture transmission) equipment, which is available through a variety of companies to anyone in the world. The U.S. Department of Defense has its own polar orbiting weather satellites, called the Defense Meteorological Satellite Program (DMSP).

The Soviet Union has polar orbiting weather satellites called Meteor, but these are not Sun-synchronous orbits (they use the Sun-synchronous orbits for the Meteor-Priroda remote sensing flights, however). The Soviets do not have geostationary weather satellites, although they had promised to launch such a satellite as part of an international weather program in 1979. Their current plans for the program, called GOMS, are unknown.

C. NAVIGATION

The United States has a navigation satellite system operated by the U.S. Navy. Originally called Transit, it was renamed the Navy Navigation Satellite System and provides two dimensional data (latitude and longitude). While not particularly suited to commercial economics, it is highly effective for naval purposes. Commercial ships have been permitted to use the system since 1967 if they care to invest in the necessary computer equipment. An improved version of Transit, called Nova, is now coming into use. The first Nova launch was in 1981; the second in 1984 (although the satellite was called Nova 3).

An even more ambitious global positioning system, called NAVSTAR, entered the testing phase in 1978 with the first four satellites. Ultimately the system will have 18 satellites and will provide three-dimensional (latitude, longitude, and altitude) data, world-wide, 24 hours a day. By the end of 1984, nine NAVSTAR satellites had been launched successfully (a tenth failed to reach orbit in 1981). These satellites are part of the NAVSTAR development program; the system is not expected to be operational until 1988.

The Soviet Union claims to have had an operational navigation satellite system for many years, but did not identify the first satellite in the series, Kosmos 1000, until 1978. A model of the satellite at the Paris Air Show had the label "Tsikada," but no satellite has had that designation at the time of launch. All the satellites which appear to serve a navigation function in the Soviet program are designated under the broad Kosmos label. Analysis by the Kettering Group has shown that there are separate satellites for civilian and military users. The Soviet system is thought to be similar to Transit.

The Soviets also seem to have decided in favor of a three-dimensional navigation satellite system, and in 1982, placed three "GLONASS" satellites into orbit with a single launch. This system is expected to be similar to NAVSTAR when it is operational. By the end of 1984, there were 15 GLONASS satellites in orbit (each set was launched three at a time), and these are also thought to be part of a developmental program.

D. GEODESY AND MAPPING

The United States has flown many geodetic flights in the interest of tying together maps of different parts of the world and for basic scientific studies to understand better the true shape of the planet. If there have been mapping flights as well, the results have not been published.

The Soviet Union professes an interest in both geodesy and mapping, but too few findings have been made available to judge how far along they are in comparison with the United States. Some flights in the Kosmos series have orbital characteristics which would support such missions.

E. EARTH RESOURCES

Remote sensing satellite are designed to look down at the Earth from space to search for mineral deposits, oil fields, forest fires, pollution sources, and diseased trees and agricultural crops. Using remote sensing data, crop inventories can be made, snowfall and water status reported, and fisheries run more efficiently. Since 1972, the United States has launched 5 Landsat satellites for remote sensing purposes. At this time, the Government has decided not to launch any more satellites, but hopes that the private sector will take over that role. Legislation passed Congress in 1984 (P.L. 98-365) to facilitate transfer of the remote sensing

program to the private sector, and the Department of Commerce (which has operational responsibility for the Landsat series) has selected a contractor. The Government indicated during negotiations that it would be willing to provide $250 million to the contractor, but at the end of 1984, the Office of Management and Budget was showing great reluctance to provide initial funding for FY86 and the transfer was in question.

The Soviet Union has developed a great interest in remote sensing. Crews on board Salyut space stations spend a great deal of their time performing Earth resources investigations with a variety of cameras, including a six channel multispectral camera developed by East Germany. There also have been two flights of Meteor-Priroda satellites which were placed in Sun-synchronous orbits. A third series of remote sensing flights is launched under the Kosmos designation, and are indistinguishable from military reconnaissance flights in terms of orbital parameters and lifetimes. The spacecraft remain in orbit for only two weeks, after which they are recovered, suggesting that they are using film. Although some Western analysts count these as reconnaissance rather than Earth resources missions, this report classifies them as remote sensing since there is no logical reason for the Soviets to specify that these flights, in particular, are for remote sensing, when ordinarily they would simply say nothing about their mission.

The Soviets are also experimenting with advanced sensors for Earth resources sensing in the Meteor 2 series of flights. In 1983, the Soviets launched what may be the first of a new series of remote sensing satellites. Placed in a Sun-synchronous orbit, it was given only a Kosmos designation (K 1484), and no other details were reported.

F. SEARCH AND RESCUE

In 1984, the Soviet Union and the members of SARSAT (the United States, Canada, France, and Britain) signed an agreement providing for the operational phase of the KOSPAS/SARSAT system which is used to locate ships and aircraft in distress. Transponders on Soviet navigation satellites and U.S. NOAA weather satellites pick up signals from emergency locator transmitters on ships and aircraft and relay them to ground stations and control centers in the Soviet Union, United States, Canada, France, Norway and Britain. The Soviet transponders are developed by the Soviets themselves and are called KOSPAS; the transponders on the U.S. satellites are developed cooperatively by the United States, France, and Canada and are called SARSAT. At the end of 1984, three KOSPAS and one SARSAT transponders were in orbit, and more than 250 lives had been been saved because of the system, according to NOAA officials.

CHAPTER FOUR: SPACE SCIENCE

Both the United States and the Soviet Union have sent probes to fly-by, orbit, and/or land on other planets. So far, the United States has sent probes to Mercury, Venus, the Moon, Mars, Jupiter, and Saturn, and one is now enroute to Uranus. The Soviet Union has sent probes to Venus, the Moon, and Mars. Both countries also have programs for earth orbital science.

A. EARTH-ORBITAL SPACE SCIENCE

The history of Earth orbiting satellites for space science studies began with the very first launches of spacecraft. As discussed at the beginning of this report, the decision to launch satellites was made as part of the International Geophysical Year (IGY), and both Sputnik 1 and Explorer 1 were launched in support of the IGY.

The United States has conducted a large number of launches for Earth orbiting space science missions. The Explorer program is a series of small satellites devoted to a particular scientific goal (such as gamma ray astronomy). If successful, the sensors may be adapted and flown on larger, observatory-class satellites. Many of the Explorer missions involve international participation.

By the end of 1984, over 60 Explorer satellites had been flown. Some study the interaction between the sun and Earth in disciplines such as air density, energetic particles, geodesy, ionospheric research, magnetospheric research, and solar physics. Other Explorer satellites are dedicated to astronomy, including wavelengths in the x-ray, gamma-ray, ultraviolet, and

radio ranges.

Larger observatory-class satellites have also been launched by the United States. To date, these have included the Orbiting Geophysical Observatory (OGO), Orbiting Solar Observatory (OSO), Orbiting Astronomical Observatory (OAO), and High Energy Astronomy Observatorty (HEAO) programs. The next U.S. observatory-class spacecraft is the Space Telescope, which will be the first optical telescope in orbit, and is scheduled for launch in 1986. NASA is also planning a Gamma Ray Observatory for launch in 1988.

The Soviet Union launched its first geophysical observatory in 1958 (Sputnik 3), but has not used Earth orbit as a base for free-flying scientific spacecraft as extensively as has the United States. They launched four Proton satellites in the 1965-1968 time period to study cosmic rays, but although these were large satellites, it is generally thought in the West that the true objective was to test the new launch vehicle which placed these satellites in orbit (the "D" or Proton vehicle), rather than to acquire scientific data.

The Prognoz program, of which there have been nine flights since 1971, is the closest the Soviets have come to observatory-class spacecraft performing multiple missions. The first eight of these concentrated on atmospheric studies, but the most recent, Prognoz 9, launched in 1983, is performing radio astronomy studies. Also in 1983, the Soviets launched the Astron satellite, which is a large observatory-class satellite performing research in the x-ray and ultraviolet wavelengths.

Space science research has also been conducted on the space stations launched by both the United States and Soviet Union. For example, the U.S. Skylab carried the Apollo Telescope Mount dedicated to studies of the

Sun, and a radio telescope was deployed from Salyut 6. Astronomical studies were conducted on Salyut 1 and 4, and to a small extent on Salyut 7.

B. UNMANNED LUNAR EXPLORATION

The first attempts to send spacecraft to the Moon were either fly-bys or probes that were intended to strike the Moon without surviving the impact. In 1958, the United States began a double series of Pioneer flights--one to photograph the far side of the Moon and the other to fly by it. All four launch attempts in that year failed to reach the Moon. In January 1959, the Soviets launched Luna 1 which apparently missed the Moon. The United States followed in March 1959 with Pioneer 4 which went by the Moon and circled the Sun. U.S. plans then were to follow up with four more, larger Pioneer series lunar orbit flights during the course of 1959 and 1960, but all of these failed to reach even Earth orbits. In fact, a U.S. probe did not reach the Moon until Ranger 4 fell on the far side of the Moon in 1962. In September 1959, the Soviet Luna 2 struck the Moon near its visible center, delivering metal plaques bearing the Soviet coat of arms. In October 1959, Luna 3 flew by the Moon and took photographs of the far side, never seen before, which were returned to Earth by radio facsimile. Still later, the U.S. Ranger 7, 8, and 9 flights (1964-1965) returned spectacular TV pictures of the Moon up to the moment that they impacted the lunar surface.

The next phase of unmanned lunar exploration used spacecraft to make survivable landings. The seven U.S. Surveyor spacecraft returned almost 100,000 pictures of the lunar surface and dug holes in the surface by remote control to determine the chemical composition of the lunar soil.

The Soviet Union attempted landings as early as 1963, but later admitted that Luna 4, 5, 6, 7, and 8 failed to achieve a survivable landing. Additionally, one unnamed flight and Kosmos 60 were lunar failures which did not leave Earth orbit. When Luna 9 in 1966 finally reached the surface, the landing was not as gentle as a Surveyor landing, and the television camera returned only 27 pictures of the surroundings. Luna 13 performed impact testing of the soil with an extendable arm.

Orbiters were used at about the same time as the landers. The five U.S. Lunar Orbiters returned extensive data about the lunar surface that were used to select landing sites for the manned Apollo missions. The Soviet Luna 10 reached a successful orbit before the first U.S. Lunar Orbiter, and returned data about the composition of the lunar surface and gravity anomalies. Luna 12 in 1966 finally returned a few pictures to supplement earlier Soviet pictures taken of the far side by Luna 3 in 1959 and Zond 3 in 1965, but the Soviet pictures did not have the clarity, detail, or variety of the five sets of Lunar Orbiter views. Luna 14 seems only to have been an extension of the work of the non-picture-taking Luna 10. Heavier satellites were later placed in lunar orbit (Luna 19 in 1971 and Luna 22 in 1974) which remained under active control for more than a year, gathering a wide variety of synoptic data and some pictures.

Zond 5 and 6, the 1968 unmanned precursors to projected later manned flights, returned actual photographs to Earth in the same manner as Apollo 8. Zond 7 in 1969 and Zond 8 in 1970 performed tasks similar to those of the two preceding Zonds.

The Soviet Union has launched two special types of lunar vehicles for exploration of the Moon in lieu of human crews. Three missions (Luna 16 in 1970, Luna 20 in 1972, and Luna 24 in 1976) returned a total

of approximately 330 grams of lunar material to Earth (compared with 380 kilograms returned by the U.S. Apollo crews). Three other flights that may have been intended to return samples failed (Luna 15, 18, and 23).

The other special Soviet program placed roving vehicles called Lunokhods on the lunar surface. Lunokhod 1 (Luna 17) landed on November 17, 1970, and continued to function until October 4, 1971, traveling 10,540 meters over the surface, and returning 20,000 television views, 200 detailed panoramas, 500 soil-property tests, 25 soil chemical analyses, and a number of astronomical observations with its X-ray telescope. Lunokhod 2 (Luna 21) in 1973 operated for 3 months, but traveled 37,000 meters in that time, and returned proportionately more data and pictures despite its shorter life.

C. U.S. PLANETARY MISSIONS

The U.S. Mariner program of three-axis stabilized probes has involved the launch of ten vehicles, six of which returned planetary data. Mariner 2 and 5 brought back indirect readings of Venus. Mariner 4, 6, 7, and 9 brought back increasingly good pictures of the surface features of Mars. Mariner 10 not only returned good pictures of the cloud patterns of Venus, but made three photographic passes by Mercury with good results.

The Pioneer series of spin-stabilized spacecraft has seen 18 launch attempts, of which 12 were at least partially successful. Pioneer 1 and 3 did not reach their intended trajectories to the Moon, but did send back data about Earth's atmosphere. Pioneer 4 successfully returned data as it flew past the Moon and entered heliocentric orbit. Pioneers 5 through 9 were designed to study the area of space between the Earth and Sun, and did so successfully. Pioneers 6, 7, 8, and 9, launched between 1965 and 1968,

were still returning data at the end of 1984.

Pioneers 10 and 11 were the first planetary probes of the Pioneer series, and were launched to investigate Jupiter, Saturn, and the interplanetary medium. Both probes sent back pictures of Jupiter in 1973 and 1974 respectively; Pioneer 10 then was placed on a trajectory out of the solar system, while Pioneer 11 continued on to a successful encounter with Saturn in 1979. Pioneer 10 continues to return data, and in 1983 passed out of the solar system, the first object from planet Earth to do so.

Pioneer Venus 1 and 2 were launched in 1978 and reached Venus in December of that year. Pioneer Venus 1 is an orbiter, which at the end of 1984 was continuing to return data about Venus. The spacecraft carries a radar altimeter for studying surface features. Pioneer Venus 2 consisted of five separate probes, all of which descended through the Venusian atmosphere to make in situ measurements of its characteristics. Although they were not designed to withstand landings on the planet, two of the probes did survive and transmitted data for as long as 67 minutes after impact.

Viking 1 and 2, launched in 1975, each were orbiter/lander combinations. The orbiters mapped the surface of Mars and collected clear views of Deimos and Phobos, the two Martian moons. The landers sent back color pictures from the surface, and their on-board laboratories conducted a search for life with puzzling, inconclusive findings.

Voyager 1 and 2 were launched in 1977 toward Jupiter and the outer planets. During 1979 they returned astonishing color pictures not only of Jupiter but also of its larger moons, each unique and unexpected in appearance. In 1980, Voyager 1 returned equally exciting pictures of Saturn and its moons, including Titan, and Voyager 2 returned data on Saturn in 1981. Voyager 2 is now enroute to Uranus with closest approach expected in 1986.

D. SOVIET PLANETARY MISSIONS

In 1961, the Soviets launched their first Venus probe, Venera 1, but it was not operating when it reached the planet. In 1962, there were three more Venus attempts and three Mars attempts, with five of these payloads stranded Earth orbit, and the sixth, Mars 1, was not operating when it reached the vicinity of that planet. Zond 1, Venera 2, and Venera 3 were not in operating condition when they reached Venus. Zond 2 made a close fly-by of Mars in non-operating condition. Zond 3 was a test flight which took pictures of the far side of the Moon and rebroadcast them to Earth as it traveled as far as the orbit of Mars.

Results improved for the Soviets when Venera 4, 5, 6, 7 and 8 all functioned and returned direct readings of Venus' atmosphere. Venera 7 survived a Venus landing and broadcast for 23 minutes from the surface. Venera 8 had similar success, plus performing soil analyses.

In 1975, two larger Soviet Venus probes, Venera 9 and 10, reached their destination and became the first spacecraft to return pictures of the surface of another planet. The orbiters returned pictures and other data for many months in orbit. The landers operated for about an hour on the surface, and their cameras returned good pictures of the far side surface, relayed via the orbiters. This was a remarkable feat, considering the 485°C temperature.

Venera 11 and 12 were sent to Venus in 1978, at approximately the same time as the U.S. Pioneer-Venus probes. No photographs were returned by these spacecraft, and Soviet scientists have indicated that the imaging systems failed. Data were returned on other aspects of the Venusian atmosphere and surface. In late 1981, Venera 13 and 14 were launched, and they landed on March 1 and 5, 1982. The spacecraft sent back color photographs of the

surface, and carried drills for obtaining core samples for chemical analysis.

In 1983, the Soviets launched Venera 15 and 16 which, instead of carrying the traditional landers, were equipped with radars to study the surface of Venus from orbit. Venera 15 entered orbit around Venus on October 10, followed four days later by Venera 16. The radars have a resolution of 1-2 kilometers, and are in polar orbits around the planet so provide data on parts of the planet not seen by the U.S. Pioneer-Venus orbiter or from Earth-based telescopes.

In December 1984, the Soviets launched two VEGA spacecraft, which will study both Venus and Halley's Comet. At Venus, the two spacecraft will drop off landers, and balloons developed by French scientists which will slowly drift through Venus' atmosphere to make in situ measurements. The main part of the spacecraft will continue on to an encounter with Halley's Comet in 1986, and VEGA 1 will be the first probe to arrive there (others will be launched by the European Space Agency and Japan). The United States has agreed to track the balloons in Venus' atmosphere for the French, and the Soviet spacecraft as they reach Halley's Comet, to provide data to ESA with which to target its Giotto spacecraft.

The Soviets have not had very much success with their Mars probes. In 1971, two orbiter/lander spacecraft, Mars 2 and 3, were launched. Mars 2 landed on the surface but no further mention was made of it by the Soviets, suggesting that it failed; Mars 3 made a survivable landing, but signals ceased after 20 seconds, before the first complete picture was received on Earth. The orbiters did return data. In 1973, four spacecraft (Mars 4, 5, 6 and 7) were launched. Mars 4 and 5 were intended as orbiters working with the Mars 6 and 7 landers. Of these four only Mars 5 attained an orbit and Mars 6 a landing. Mars 6 returned direct readings within the atmosphere but signals ceased before it reached the surface.

TABLE 4. Summary of Lunar Distance Flight Attempts

Launch date	Spacecraft name	Country	Weight (kg)	Mission Objective	Results
1958					
Aug. 17	Pioneer 0	US	38	Orbit Moon	Failure--exploded 16 km up.
Oct. 11	Pioneer 1	US	38	Orbit Moon	Failure--climbed 113,830 km, fell back over South Pacific.
Nov. 8	Pioneer 2	US	39	Orbit Moon	Failure--climbed 1,550 km, fell near Africa.
Dec. 6	Pioneer 3	US	6	Fly by Moon	Failure--climbed 102,320 km, fell back over Africa.
1959					
Jan. 2	Luna 1	USSR	361	Strike Moon	Partial--missed Moon by 5-6,000 km, entered solar orbit.
Mar. 3	Pioneer 4	US	6	Fly by Moon	Success--passed Moon at 60,050 km, entering solar orbit.
Sept. 12	Luna 2	USSR	390	Strike Moon	Success--struck 435 km from visible center.
Sept. 24	Pioneer P-1	US	170	Orbit Moon	Failure--exploded in static test before launch.
Oct. 4	Luna 3	USSR	435	Photo far side	Success--returned pictures of 70 percent of far side of Moon.
Nov. 26	Pioneer P-3	US	169	Orbit Moon	Failure--shroud tore away in launch, payload impacted near Africa.
1960					
Sept. 25	Pioneer P-30	US	176	Orbit Moon	Failure--impacted in Africa.
Dec. 15	Pioneer P-31	US	176	Orbit Moon	Failure--climbed 13 km and exploded.
1961					
Aug. 23	Ranger 1	US	306	Vehicle test	Failure--intended to climb to 1,102,850 km, but stayed in low Earth orbit.
Nov. 18	Ranger 2	US	306	Vehicle test	Failure--intended to climb to 1,102,850 km, but stayed in low Earth orbit.
1962					
Jan. 26	Ranger 3	US	330	TV, hard land	Partial--missed Moon by 36,808 km, no TV pictures or landed instruments.

TABLE 4. Summary of Lunar Distance Flight Attempts--continued

Launch date	Spacecraft name	Country	Weight (kg)	Mission Objective	Results
Apr. 23	Ranger 4	US	331	TV, hard land	Partial--timer failed, fell on far side of Moon, no picture.
Oct. 18	Ranger 5	US	342	TV, hard land	Partial--power failure, missed Moon by 725 km, entered solar orbit.
1963					
Jan. 30	Unannnounced	USSR	1,400?	Moon soft land	Failure--Earth orbit only.
Apr. 2	Luna 4	USSR	1,422	Moon soft land	Partial--missed Moon by 8,500 km, barycentric or solar orbit.
1964					
Jan. 30	Ranger 6	US	365	TV before strike	Partial--on target, but no pictures taken.
Jul. 28	Ranger 7	US	366	TV before strike	Success--returned 4,308 pictures of Moon to impact.
Dec. 11	Centaur 2	US	952	Vehicle test	Failure--did not restart and fell in Australia.
1965					
Feb. 17	Ranger 8	US	367	TV before strike	Success--returned 7,137 pictures of Moon to impact.
Mar. 2	Centaur AC 5	US	635	Vehicle test	Failure--exploded at pad.
Mar. 12	Kosmos 60	USSR	1,470	Moon soft land	Failure--Earth orbit only.
Mar. 21	Ranger 9	US	366	TV before strike	Success--returned 5,814 pictures of Moon to impact.
May 9	Luna 5	USSR	1,476	Moon soft land	Partial--missed Moon by 160,000 km, entered barycentric or solar orbit.
June 8	Luna 6	USSR	1,442	Moon soft land	Partial--missed Moon by 160,000 km, entered solar or barycentric orbit.
Jul. 18	Zond 3	US	890?	Photo far side	Success--returned 25 pictures, entered solar orbit.
Aug. 11	Centaur 3	US	952	Vehicle test	Success--reached 820,824 km out with Surveyor dynamic model, in barycentric orbit.
Oct. 4	Luna 7	USSR	1,506	Moon soft land	Partial--retrofired early, fell on Moon.
Dec. 3	Luna 8	USSR	1,552	Moon soft land	Partial--retrofired late, fell on Moon.

TABLE 4. Summary of Lunar Distance Flight Attempts--continued

Launch date	Spacecraft name	Country	Weight (kg)	Mission Objective	Results
1966					
Jan. 31	Luna 9	USSR	1,583	Moon soft land	Success--returned 27 pictures from lunar surface.
Feb. 26	Apollo-Saturn 201	US	15,331	Vehicle test	Success--flew suborbitally to land in Pacific.
Mar. 1	Kosmos 111	USSR	1,600?	Moon orbit	Failure--Earth orbit only.
Mar. 31	Luna 10	USSR	1,600	Moon orbit	Success--returned physical measurements from lunar orbit.
Apr. 8	Centaur 4	US	771	Vehicle test	Failure--low Earth orbit only.
May 30	Surveyor 1	US	995	Moon soft land	Success--returned 11,237 pictures from lunar surface.
Jul. 1	Explorer 33	US	93	Moon orbit	Partial--failed to approach Moon; in barycentric orbit.
Jul. 5	Apollo-Saturn 203	US	26,535	Vehicle test	Success--simulated in Earth orbit a Saturn V flight.
Aug. 10	Lunar Orbiter 1	US	387	Moon orbit	Success--returned 414 pictures of potential landing sites on Moon.
Aug. 24	Luna 11	USSR	1,604?	Moon orbit	Partial--failed to return pictures from lunar orbit.
Aug. 25	Apollo-Saturn 202	US	20,275	Vehicle test	Success--simulated reentry in suborbital flight.
Sep. 20	Surveyor 2	US	1,000	Moon soft land	Partial--stabilization failed, struck Moon.
Oct. 22	Luna 12	USSR	1,625?	Vehicle test	Success--returned pictures of Moon.
Oct. 26	Centaur 2	US	726	Vehicle test	Success--mass model of Surveyor carried to 465,032 km.
Nov. 6	Lunar Orbiter 2	US	390	Moon orbit	Success--returned 422 pictures of Apollo sites, far side.
Dec. 21	Luna 13	USSR	1,595?	Moon soft land	Success--returned pictures and soil density measures.
1967					
Jan. 27	Apollo-Saturn 204	US	20,412	Capsule test	Failure--burned on pad in training exercise.
Feb. 5	Lunar Orbiter 3	US	385	Moon orbit	Success--returned 307 pictures of Apollo sites.
Apr. 17	Surveyor 3	US	1,035	Moon soft land	Success--returned 6,315 pictures, dug soil with shovel.

TABLE 4. Summary of Lunar Distance Flight Attempts--continued

Launch date	Spacecraft name	Country	Weight (kg)	Mission Objective	Results
May 4	Lunar Orbiter 4	US	390	Moon orbit	Success--returned 326 pictures of large areas of the Moon.
Jul. 14	Surveyor 4	US	1,039	Moon soft land	Partial--signals ceased at touchdown on Moon.
Jul. 19	Explorer 35	US	104	Moon orbit	Success--returned data from lunar orbit.
Aug. 1	Lunar Orbiter 5	US	390	Moon orbit	Success--returned 424 pictures including much of far side.
Sep. 8	Surveyor 5	US	1,005	Moon soft land	Success--returned 18,006 pictures, chemical analysis of soil.
Nov. 7	Surveyor 6	US	1,008	Moon soft land	Success--returned 30,065 pictures, chemical and mechanical soil studies.
Nov. 9	Apollo 4	US	42,506	Vehicle test	Success--simulated full lunar return reentry in Earth orbit.
1968 Jan. 7	Surveyor 7	US	1,040	Moon soft land	Success--returned 21,274 pictures, chemical analysis of soil from trench it dug.
Jan. 22	Apollo 5	US	14,379	Vehicle test	Success--tested lunar module in Earth orbit.
Mar. 2	Zond 4	USSR	5,800?	Vehicle test	Partial--flew to lunar distance but recovery in doubt.
Apr. 4	Apollo 6	US	42,577	Vehicle test	Partial--did not go to lunar distance, but recovered payload.
Apr. 7	Luna 14	USSR	1,615?	Moon orbit	Success--returned data on lunar mass distribution.
Sep. 14	Zond 5	USSR	5,800?	Circumlunar	Success--ballistic reentry with biological subjects and pictures.
Oct. 11	Apollo 7	US	20,577	Manned test	Success--flew in Earth orbit.
Nov. 10	Zond 6	USSR	5,800?	Circumlunar	Success--lifting reentry with biological specimens and pictures.
Dec. 21	Apollo 8	US	43,654	Moon orbit	Success--men in lunar orbit; recovered.
1969 Mar. 3	Apollo 9	US	47,167	Manned test	Success--tested lunar module rendezvous, crew recovered.
May 18	Apollo 10	US	48,638	Moon orbit	Success--tested lunar module rendezvous at Moon, crew recovered.

TABLE 4. Summary of Lunar Distance Flight Attempts--continued

Launch date	Spacecraft name	Country	Weight (kg)	Mission Objective	Results
Jul. 13	Luna 15	USSR	5,800?	Moon soft land	Partial--lunar orbit success, but landing failed.
Jul. 16	Apollo 11	US	49,698	Moon soft land	Success--first manned landing on Moon and return.
Aug. 7	Zond 7	USSR	5,800?	Circumlunar	Success--lifting reentry; color and b/w photographs.
Sep. 23	Kosmos 300	USSR	5,800?	Moon soft land	Failure --Earth orbit only.
Oct. 22	Kosmos 305	USSR	5,800?	Moon soft land	Failure--Earth orbit only.
Nov. 14	Apollo 12	US	49,804	Moon soft land	Success--manned lunar landing and return with part of Surveyor 3.
1970					
Apr. 11	Apollo 13	US	49,990	Moon soft land	Partial--explosion in service module required emergency return to Earth.
Sep. 12	Luna 16	USSR	5,800?	Moon soft land	Success--made automated sample return.
Oct. 20	Zond 8	USSR	5,800?	Circumlunar	Success--ballistic reentry with photograph.
Nov. 10	Luna 17	USSR	5,800?	Moon soft land	Success--landed automated roving vehicle for long term exploration.
1971					
Jan. 31	Apollo 14	US	46,346	Moon soft land	Success--manned lunar landing and return.
July 26	Apollo 15	US	52,759	Moon soft land	Success--manned lunar landing, roving vehicle, safe return.
Sep. 2	Luna 18	USSR	5,800?	Moon soft land	Partial--lunar orbit success, but crashed on landing.
Sep. 28	Luna 19	USSR	5,800?	Moon orbit	Success--returned photographs and other data.
1972					
Feb. 14	Luna 20	USSR	5,800?	Moon soft land	Success--made automated sample return.
Apr. 16	Apollo 16	US	48,606	Moon soft land	Success--manned lunar landing, roving vehicle, safe return.
Dec. 7	Apollo 17	US	46,825	Moon soft land	Success--manned lunar landing, roving vehicle, safe return.
1973					
Jan. 8	Luna 21	USSR	5,800?	Moon soft land	Success--landed automated roving vehicle for long term exploration.

TABLE 4. Summary of Lunar Distance Flight Attempts--continued

Launch date	Spacecraft name	Country	Weight (kg)	Mission Objective	Results
Jun. 10	Explorer 49	US	328	Moon orbit	Success--radio astronomy from far side of Moon.
1974					
May 29	Luna 22	USSR	5,800?	Moon orbit	Success--returned pictures and data.
Oct. 28	Luna 23	USSR	5,800?	Moon soft land	Partial--landed safely, but drill damaged so no sample returned.
1976					
Aug. 9	Luna 24	USSR	5,800?	Moon soft land	Success--made automated sample return.

1. The table includes all known attempts to send payloads to the Moon or to distances from Earth equal to the distance of the Moon from Earth, together with test flights in Earth orbit of lunar-associated hardware. It cannot include Soviet flight failures which did not reach Earth orbit because these are not in the public domain. Hence, the cumulative weight of Soviet payloads almost certainly understates reality.

2. In a very few instances, the mission has been assigned by inference, in terms of the context of the time in which it took place.

3. The test of success or failure is somewhat arbitrary. Any flight staying in relatively low Earth orbit as well as not achieving Earth orbit is counted as a failure. Flights which at least approached the Moon, although not achieving the estimated goal received the rating of partial success.

4. The Soviet label Luna was applied after the fact to the first flights which at the time were simply called Cosmic Rockets, with the third one called an Automatic Interplanetary Station (AIS 1). Luna 1 was also called Mechta (Dream).

SOURCES: Soviet data are from Soviet TASS bulletins for the most part, supplemented by inferential judgments that some Earth orbital flights were almost certainly lunar attempts which failed, based upon the timing of the launch, the nature of the debris in Earth orbit, the launch vehicle used, and the orbital path chosen. U.S. data are based mostly on NASA press releases, although the first lunar attempt was sponsored and reported on by the Advanced Research Projects Agency (ARPA) of the Department of Defense before the creation of NASA. Estimated weights of Luna 11, 12, 13 and 14 by D.R. Woods. Weights of Luna 15 on, and Zond 4-8 were estimated by the Royal Aircraft Establishment.

TABLE 5. Summary of Planetary Distance Flight Attempts

Launch date	Spacecraft name	Country	Weight (kg)	Mission Objective	Results
1960					
Mar. 11	Pioneer 5	US	43	Interplanetary toward Sun	Success--returned data from 36.2 million kilometers.
Oct. 10	Unacknowledged	USSR	640?	Mars	Failure--did not reach Earth orbit.
Oct. 14	Unacknowledged	USSR	640?	Mars	Failure--did not reach Earth orbit.
1961					
Feb. 4	Tyazheliy Sputnik 4	USSR	640?	Venus	Failure--Earth orbit only.
Feb. 14	Venera 1	USSR	644	Venus	Partial--communications failed; passed Venus at 100,000 km.
1962					
Jul. 22	Mariner 1	US	202	Venus flyby	Failure--destroyed at 160 km altitude.
Aug. 25	Unacknowledged	USSR	890?	Venus	Failure--Earth orbit only.
Aug. 27	Mariner 2	US	203	Venus flyby	Success--passed Venus at 34,853 km.
Sep. 1	Unacknowledged	USSR	890?	Venus	Failure--Earth orbit only.
Sep. 12	Unacknowledged	USSR	890?	Venus	Failure--Earth orbit only.
Oct. 24	Unacknowledged	USSR	890?	Mars	Failure--Earth orbit only.
Nov. 1	Mars 1	USSR	894	Mars	Partial--communications failed, passed Mars at 191,000 km.
Nov. 4	Unacknowledged	USSR	890?	Mars	Failure--Earth orbit only.
Nov. 11	Kosmos 21	USSR	890?	Venus test	Failure--Earth orbit only.
1964					
Mar. 27	Kosmos 27	USSR	890?	Venus	Failure--Earth orbit only.
Apr. 2	Zond 1	USSR	890?	Venus	Partial--communications failed, passed Venus at 100,000 km.
Nov. 5	Mariner 3	US	261	Mars flyby	Failure--shroud did not separate, thrown into wrong orbit.
Nov. 28	Mariner 4	US	261	Mars flyby	Success--returned 22 pictures.
Nov. 30	Zond 2	USSR	890?	Mars	Partial--communications failed, passed Mars at 1,500 km.

TABLE 5. Summary of Planetary Distance Flight Attempts--continued

Launch date	Spacecraft name	Country	Weight (kg)	Mission Objective	Results
1965					
Jul. 18	Zond 3	USSR	890?	Mars test	Success--returned 25 pictures of Moon's far side, retransmitted increasing distances.
Nov. 12	Venera 2	USSR	963	Venus flyby	Partial--communications failed, passed Venus at 24,000 km.
Nov. 16	Venera 3	USSR	960	Venus land	Partial--communications failed, struck Venus 450 km from visible center.
Nov. 23	Kosmos 96	USSR	960?	Venus	Failure--Earth orbit only.
Dec. 16	Pioneer 6	US	61	Interplanetary toward Sun	Success--returned data.
1966					
Aug. 17	Pioneer 7	US	61	Interplanetary away from Sun	Success--returned data.
1967					
Jun. 12	Venera 4	USSR	1,106	Venus land	Success--returned direct readings of atmosphere to 25 km altitude.
Jun. 14	Mariner 5	US	245	Venus flyby	Success-returned data, passed Venus at 4,094 km.
Jun. 17	Kosmos 167	USSR	1,100?	Venus	Failure--Earth orbit only.
Dec. 13	Pioneer 8	US	66	Interplanetary away from Sun	Success--returned data.
1968					
Nov. 8	Pioneer 9	US	67	Interplanetary toward Sun	Success--returned data.
1969					
Jan. 5	Venera 5	USSR	1,130	Venus land	Success--returned direct readings of atmosphere to near surface.
Jan. 10	Venera 6	USSR	1,130	Venus land	Success--returned direct readings of atmosphere to near surface.
Feb. 25	Mariner 6	US	380	Mars flyby	Success--returned 24 pictures and other data.
Mar. 27	Mariner 7	US	380	Mars flyby	Success--returned 31 pictures and other data.
Aug. 27	Pioneer E	US	66	Interplanetary	Failure--destroyed by range safety.

TABLE 5. Summary of Planetary Distance Flight Attempts--continued

Launch date	Spacecraft name	Country	Weight (kg)	Mission Objective	Results
1970					
Aug. 17	Venera 7	USSR	1,180	Venus soft land	Success--sent back data from atmosphere and surface of Venus.
Aug. 22	Kosmos 359	US	1,180	Venus soft land	Failure--Earth orbit only.
1971					
May 8	Mariner 8	US	1,029	Mars orbit	Failure--fell in Atlantic Ocean.
May 10	Kosmos 419	USSR	4,650?	Mars soft land	Failure--Earth orbit only.
May 19	Mars 2	USSR	4,650	Mars soft land	Partial--returned data from orbiter, but lander destroyed.
May 28	Mars 3	USSR	4,650	Mars soft land	Success--returned orbital data and survived landing.
May 30	Mariner 9	US	1,030	Mars orbit	Success--returned 6,786 pictures of Mars.
1972					
Mar. 3	Pioneer 10	US	258	Jupiter flyby	Success--returned pictures and other data.
Mar. 27	Venera 8	USSR	1,180?	Venus soft land	Success--atmospheric data and soil analysis returned.
Mar. 31	Kosmos 482	USSR	1,180?	Venus soft land	Failure--Earth orbit only.
1973					
Apr. 6	Pioneer 11	US	259	Jupiter, Saturn flyby	Success--returned Jupiter and Saturn pictures and data.
Jul. 21	Mars 4	USSR	4,150?	Mars orbit	Partial--returned data in flyby, but did not enter orbit.
Jul. 25	Mars 5	USSR	4,150?	Mars orbit	Success--returned data and pictures.
Aug. 5	Mars 6	USSR	4,150?	Mars soft land	Partial--returned data from flyby, but lander signals ceased.
Aug. 9	Mars 7	USSR	4,150?	Mars soft land	Partial--returned data from flyby, but lander missed by 1,300 km.
Nov. 3	Mariner 10	US	504	Venus, Mercury flyby	Success--returned pictures from Venus and encountered Mercury three times.

TABLE 5. Summary of Planetary Distance Flight Attempts--continued

Launch date	Spacecraft name	Country	Weight (kg)	Mission Objective	Results
1974					
Dec. 10	Helios 1	German Fed. Rep./US	370	Sun approach	Success--returned data.
1975					
Jun. 8	Venera 9	USSR	4,936	Venus soft land	Success--returned pictures and other data.
Jun. 14	Venera 10	USSR	5,033	Venus soft land	Success--returned pictures and other data.
Aug. 20	Viking 1	US	3,400	Mars soft land	Success--returned pictures and other data.
Sep. 9	Viking 2	US	3,400	Mars soft land	Success--returned pictures and other data.
1976					
Jan. 15	Helios 2	German Fed. Republic	376	Sun approach	Success--returned data.
1977					
Aug. 20	Voyager 2	US	700	Jupiter, Saturn, Uranus flybys	Success--returned pictures and data from Jupiter.
Sep. 5	Voyager 1	US	700	Jupiter, Saturn flybys	Success--returned pictures and data from Jupiter and Saturn.
1978					
May 20	Pioneer Venus 1	US	549	Venus orbit	Success--returned data and pictures.
Aug. 8	Pioneer Venus 2	US	904	Venus probe	Success--five vehicles returned direct data from atmosphere.
Sep. 9	Venera 11	USSR	3,940?	Venus soft land	Success--returned data from surface.
Sep. 14	Venera 12	USSR	3,940?	Venus soft land	Success--returned data from surface.
1981					
Oct. 20	Venera 13	USSR	3,940?	Venus soft land	Success--landed on March 1, 1982.
Nov. 4	Venera 14	USSR	3,940?	Venus soft land	Success--landed on March 5, 1982.
1983					
June 2	Venera 15	USSR	3,940?	Venus orbit	Success--achieved orbit Oct. 10, 1983. Carries radar.

TABLE 5. Summary of Planetary Distance Flight Attempts--continued

Launch date	Spacecraft name	Country	Weight (kg)	Mission Objective	Results
June 7	Venera 16	USSR	3,940?	Venus orbit	Success--achieved orbit Oct. 14, 1983. Carries radar.
1984					
Dec. 15	VEGA 1	USSR	4,000?	Venus land, Halley's Comet fly-by	Enroute
Dec. 21	VEGA 2	USSR	4,000?	Venus land, Halley's Comet fly-by	Enroute

1. The table includes all known attempts to send payloads to the planets or into solar orbit, not including those intended to go to the Moon which only incidentally may have escaped barycentric orbit to enter heliocentric orbit. It cannot include additional Soviet flight failures which did not reach Earth orbit, when not in the public domain. The only year in which there had been persistent reports of Soviet intentions to launch planetary flights for which there is no public record of failures is 1969. This could mean that Mars flights using the D-1-e vehicle began in that year, but failed to reach Earth orbit.

2. Weights listed are in kilograms, with a second column showing a running total of kilograms for all flights to data of the same national origin.

3. In a few instances, the mission has been assigned by inference, in terms of the context of the time in which it took place. Some of the Soviet flights to the planets may have been orbiters or landers, but no attempt has been made to guess the mission other than that of the planet name.

4. The test of success or failure is somewhat arbitrary. Any flight staying in relatively low Earth orbit as well as those not achieving Earth orbit are counted as failures. Flights at least approaching interplanetary distances although not achieving their estimated goal received the rating of partial success.

SOURCES: Soviet data are from Soviet TASS bulletins for the most part, supplemented by inferential judgments that some Earth orbital flights were almost certainly planetary attempts which failed, based on the timing of the launch, the nature of the debris in Earth orbit, the launch vehicle used, and the orbital path chosen. U.S. data are based mostly on NASA press releases. Weight estimates for the more recent Mars and Venus flights by the Russians have been varied from the weight of Mars 2 and 3 at the suggestion of D.R. Woods and C.P. Vick, to reflect approximate energy requirement effects on payloads.

CHAPTER FIVE: MILITARY SPACE ACTIVITIES

A. MILITARY VERSUS CIVIL SPACE MISSIONS

There seems to be little difference between the Soviet and U.S. space programs as to general purpose and direction. Both are broadly based, with elements of scientific exploration, technology development, national image building, practical applications, and military support services. Cumulatively, about 54 percent of U.S. launches have been conducted for the Department of Defense, with 43 percent for primarily military purposes, while approximately 66 percent of successful Soviet launches have been for primarily military purposes.

The distinction between "military" and "civilian" launches has always been arbitary to a certain extent, since satellites can be used for both sectors. For example, communications satellites can carry either military or civilian traffic, and navigation satellites are used by both the military and civilian communities. This issue is becoming increasingly blurred with the advent of the U.S. space shuttle, since individual payloads may be "military," such as a communications satellite, while the predominant nature of the mission is civilian. Since the statistics in Table 6 reflect number of launches, rather than number of payloads, a true count of military payloads cannot be made. In 1984, for example, two shuttle flights deployed satellites which are being leased by the Department of Defense and would normally be classified as military payloads (the LEASAT/ Syncom satellites). The other payloads on the shuttle flights, however, were definitely civilian, so the launch is counted as civilian.

In the case of Soviet satellites, they claim that all are for scientific purposes, so distinguishing between military and civilian launches is even more difficult and must rely upon assumptions made by Western analysts as to what mission is being performed. Thus, the numbers provided in Table 6 should be used with extreme caution, and only as a basis for general comparisons between the two programs.

B. MANAGEMENT OF SPACE PROGRAMS

Under the terms of the National Aeronautics and Space Act of 1958, one portion of the U.S. space program is run by a civilian organization, the National Aeronautics and Space Administration (NASA), while another is operated by the Department of Defense (DOD) using the Air Force as its executive agent. Other space activites are conducted by additional agencies such as the Departments of Energy, Commerce, Transportation, Agriculture and Interior, but NASA and DOD together represent more than 95 percent of the U.S. space program budget. The National Aeronautics and Space Council, a coordinating body which operated from 1958 to 1973, was abolished by President Nixon. President Reagan has created a Senior Interagency Group/Space (SIG/Space) to serve a coordinating role.

Much less is known about the Soviet pattern of organization, and the exact names of all their space organizations are not known. The Soviet Academy of Sciences plays a role in planning scientific aspects of the program, and operates some of the tracking ships. The Soviet Strategic Rocket Force conducts launches and apparently is responsible for supplying the launch vehicles. The interfaces are obscure, however, and if there are construction and testing ministries in between, little is known of them. There is no Soviet equivalent of NASA.

TABLE 6

Approximate Comparison of U.S. and Soviet Successful Space Launches --
Primarily Civil Versus Presumptively Military*

	Primarily Civil				Presumptively Specialized Military	
Year	NASA	DOD	U.S. Total	USSR	DOD	USSR
1957	0	0	0	2	0	0
1958	0	5	5	1	0	0
1959	5	0	5	3	5	0
1960	5	1	6	3	10	0
1961	10	0	10	6	19	0
1962	18	3	21	15	31	5
1963	10	2	12	10	26	7
1964	22	3	25	15	32	15
1965	24	11	35	23	28	25
1966	30	11	41	17	32	27
1967	26	8	34	20	24	46
1968	19	6	25	25	20	49
1969	21	3	24	19	16	51
1970	12	2	14	26	15	55
1971	15	7	22	23	10	60
1972	17	3	20	21	11	53
1973	12	3	15	28	8	58
1974	16	2	18	29	6	52
1975	18	3	21	29	7	60
1976	13	6	19	25	7	74
1977	13	2	15	29	9	69
1978	19	5	24	28	8	60
1979	7	5	12	27	4	60
1980	5	3	8	25	5	64
1981	11	2	13	39	5	59
1982	12	0	12	33	6	68
1983	15	0	15	40	7	58
1984	10	0	10	34	12	63
TOTAL	385	96	481	595	363	1,138

* As discussed in the text, classification is to some extent arbitrary.

C. THE NATURE OF MILITARY SPACE PROGRAMS

United States policy has been that its military flights are non-aggressive. Many of its military spacecraft are hardly distinguishable from missions conducted for civilian application purposes. Thus a message sent by satellite, or a weather report based on space observations, or navigational data used by a ship, are technically neutral in character. Often these services are of a traditional nature, simply done more speedily or cheaply by using satellites. Whether such services are aggressive is in the mind of the user, and not subject to scientific, absolute determination.

Although the U.S. Government is reluctant to discuss the subject, careful observers of military space activities have a strong conviction that the most active development of military space flights lies in the area of Earth observation. President Johnson, speaking in Nashville, Tennessee on March 15, 1967, claimed in an "off-the-record" statement widely reported at the time that the dividends of military space operations to the United States were equal to ten times everything which had been spent on space. This implied savings in the defense budget over a ten year period on the order of $400 billion, because of more precise information about military and related activities all over the world. American analysts argue that reliable information from space is one of the greatest safeguards against miscalculation by the major powers, and hence, in the absence of explicit international agreements for open skies and ground inspection, is a fair bargain in reducing the risks and costs stemming from erroneous impressions. President Carter on October 1, 1978, officially acknowledged the U.S. role in military photo-reconnaissance from space.

There is no doubt that the Soviet Union has a large and regular program of military support flights, including use of satellites for photographic

observation, early warning, electronic listening, weather reporting, communications relaying, and ship navigation. Although these space services undoubtedly enhance Soviet military capabilities, in net balance they probably are to the advantage of the United States if greater knowledge between the two superpowers makes each more cautious and less prone to error in estimates.

D. SPACE WEAPONS

One area of military space activity that is receiving greater attention now, and about which there is considerable debate as to whether it will lead to greater or less stability between the superpowers, is that of space weapons. Although they have become a matter of great debate only in the past several years, space weapons have existed since the earliest days of the space program.

1. Soviet Fractional Orbital Bombardment System (FOBS)

Ever since the days of Sputnik 1, there has been public concern about nuclear bombs dropped from orbit. The potential threat is there, but it must be qualified by many practical considerations. A bomb in orbit must be called down by signal, and on a particular orbit would fall close only to a selected path defined by the orbit, so that hitting a planned target is possible only at certain hours or days, and in a sudden emergency might not be near a useful target. It also may be subject to malfunction and might fall on a city in the country that launched it (or an ally) as well as one in an enemy country. A bomb in fixed orbit can be precisely located, and hence intercepted by another space power.

Although no country has placed nuclear bombs in orbit to date, the Soviets tested a system from 1967-1971 called a Fractional Orbital Bombardment System

(FOBS) which could be considered such a device if it became operational. FOBS was essentially a long range ICBM which would have come at the United States from around the South Pole, rather than the North Pole, thus avoiding the Ballistic Missile Early Warning System (BMEWS) radars which point to the north. This was not a technical violation of the 1967 Outer Space Treaty, which bans placing nuclear weapons in orbit, because there is no reason to assume they carried nuclear material on board the test flights, and the dummy warhead flew less than one full orbit. The pattern was to launch a satellite from the Soviet Union on a path avoiding the United States and call down the test warhead just before the end of the first orbit onto Soviet territory, while some minor debris and expended rocket casing stayed in orbit for a few more hours before decaying.

Opinion is divided in the West as to whether the Soviets ceased testing the FOBS system in 1971 because they determined it was not worthwhile, or because it is operational. Two facts have become available in recent years, however, which tend to support the thesis that the system was judged to be of little value. In the 1979 SALT II agreement (which was never ratified), the Soviets agreed to dismantle 18 "fractional orbital missile launchers" at Tyuratam, an apparent reference to FOBS. The fact that they were willing to give them up suggests that they were not considered terribly valuable. Second, in its report on the FY1985 authorization bill for DOD, the House Armed Services Committee reported that the reason the United States had developed an antisatellite system in the 1960's (see below) was because of concern about FOBS, and that when FOBS "was not deployed," the United States dismantled its ASAT system. There is some question as to whether this conclusion is correct since only the FOBS test flights flew over the site at which the U.S. ASAT system was based; if FOBS had been used

operationally it would have had to fly a completely different trajectory to hit the United States and could not have been intercepted from Johnston Island. Nevertheless, the comment that the U.S. ASAT system was dismantled because FOBS was not deployed strengthens the supposition that the FOBS program was not successful.

2. Early U.S. and Soviet Antisatellite Missiles

The first test of an antisatellite (ASAT) device was conducted by the United States in 1959. A Bold Orion air-launched missile was used to score a deliberate near miss on the U.S. Explorer 6 satellite. Although the Bold Orion was not pursued as an ASAT device, the United States did have plans for a program called SAINT (variously described as having stood for SAtellite INspecTor, SAtellite INTerceptor, or SAtellite Inspection and NegaTion) from 1960-1962, but this program also was cancelled.

In 1962, Nikita Khrushchev stated in an interview with American newspaper editors that the Soviet Union had a missile that could "hit a fly in outer space." This was interpreted by some as an indication of an ASAT capability, perhaps using Galosh antiballistic missiles. Perhaps in response to this concern, or perhaps because of FOBS as discussed in the previous section, the United States developed its own ASAT system using missiles based on Johnston Island and Kwajalein Atoll in the Pacific. The system at Kwajalein, which used Nike-Zeus missile, was terminated in 1964, while the Johnston Island system, using Thor missiles, was declared operational by President Johnson in a 1964 speech. These facilities are believed to have been shut down in 1975. Since it employed nuclear warheads, use of the system would have violated the 1963 Limited Test Ban Treaty and the 1967 Outer Space Treaty. The Soviet Galosh system may still be capable of intercepting

satellites to about the same degree as the United States could have from its mid-Pacific installation, and similarly would violate the 1963 and 1967 treaties if used.

3. Existing Soviet Co-Orbital ASAT Device

Beginning in 1968, the Soviets began testing a co-orbital ASAT device; a total of 20 tests have been conducted so far. The most recent test was conducted in June 1982, and the Soviet Union subsequently announced a unilateral moratorium on ASAT testing, stating that it will not be the first to place ASAT weapons in orbit (but avoiding any admission that they have already tested an ASAT device). The interceptor is launched by a variant of the SS-9 booster and goes into a close co-orbit with the target satellite. In operation, the interceptor would then maneuver close to the target and explode (using a chemical explosive), destroying the operational capability of the target with shrapnel. In the tests, no satellite has actually been destroyed. Instead, the interceptor either moves off and then explodes, or is commanded to reenter. Without knowing the test objectives in each case, it is difficult to assess from open sources how successful these tests have been, but it is generally concluded in the West that approximately 50 percent of the tests have been successful.

Tests were conducted from 1968 to 1971, after which a four year hiatus occurred. Testing resumed in 1976, the year after the U.S. dismantled its missile ASAT system, and the Chinese had orbited their first prototype reconnaissance satellite. Whether these factors led to the resumption in testing, or whether the Soviets introduced a system with new technology at that time, is unknown. The United States declared the Soviet system

operational in 1977 and decided to develop its own advanced ASAT (see next section). At the same time, President Carter called on the Soviets to negotiate a treaty to ban weapons from space, and during the course of those talks in 1978-1979, the Soviets once again ceased tests of their ASAT device. When the negotiations ended (following the Soviet invasion of Afghanistan in late 1979), the ASAT tests resumed, with one test in 1980, two in 1981, and one in 1982.

The Soviet system is limited by the altitudes and inclinations at which it can be used. U.S. communications and early warning satellites are currently outside the range of the Soviet ASAT, although future developments (such as using a more capable launch vehicle) could enhance its range.

4. U.S. F-15 ASAT Device

In 1977, following the Pentagon's assessment that the Soviet ASAT system was operational, President Carter authorized DOD to develop a U.S. ASAT device. Unlike the Soviet system, which is launched from the ground like a typical satellite, the U.S. ASAT device, called a Miniature Homing Vehicle (MHV), is launched from a two-stage rocket attached to an F-15 aircraft. With this mobility, it can go to the satellite that is to be attacked, rather than waiting for the satellite to be in a correct orbital position to be intercepted from a ground launch site. The MHV would destroy its target by direct impact, and does not carry any explosive material. The U.S. ASAT system is still being developed, and is expected to be operational in 1987. During 1984, two tests were conducted of the U.S. ASAT. The first, on January 21, was termed a success by DOD, but it has not stated whether the second test, on November 13, was a success or

failure. Both tests were against points in space, and the first did not carry an actual MHV. Testing against objects in space is currently prohibited until March 1, 1985 or 15 days after the President makes certain certifications to Congress, whichever is later. The certifications are: that he is endeavoring in good faith to negotiate an agreement with the Soviets containing the strictest possible limits on ASATs, that tests against objects in space would not gravely impair such negotiations, and that testing would be consistent with the 1972 ABM Treaty. Furthermore, no more than three tests against objects in space may be conducted during FY1985.

The U.S. ASAT is limited in altitude, but its range is classified. According to statements before Congress by DOD witness, the range is less than the Soviet ASAT (reported by DOD to be at least 5,000 kilometers), but can attack satellites at any inclination. Soviet communications and early warning satellites are in different orbits than their American counterparts, with a low point only 500 kilometers above the surface. These probably are within range of the U.S. ASAT, although the low point of the orbit is over the ocean, so the F-15 might require in-flight refueling to reach the satellite, and the F-15s would have to be based in the Southern Hemisphere. Also, the Soviet satellite would be travelling at a very high velocity at that point, making an intercept difficult.

E. OCEAN SURVEILLANCE

Both the United States and Soviet Union have satellites for trying to locate ships at sea by listening for electronic emanations (from radars on the ships, for example). Only the Soviet Union, however, has a satellite system which carries an active radar for attempting to determine ship

positions. Called RORSATs (radar ocean reconnaissance satellites), they are powered by nuclear reactors, and ordinarily when the mission ends some weeks after launch, the craft separates into two parts and the portion containing the reactor in boosted into a higher orbit from which it will not decay until the radioactivity is no longer a health hazard. On two occasions, however, this maneuver has not worked correctly and the satellite has returned to Earth.

In the first instance, Kosmos 954 fell over Canada on January 24, 1978. The reentry of the satellite confirmed that it did use a nuclear reactor. After the accident, no similar flights were made for two and a half years, until April 1980. In 1981, three RORSATs were launched, and there were four in 1982. One of these (Kosmos 1402) failed to separate correctly and it reentered in two pieces on January 23 and February 7, 1983. During the incident, the Soviets revealed a new safety procedure that had been incorporated since 1978 which separates the reactor core from the rest of the satellite to ensure its complete disintegration in the atmosphere. No pieces of Kosmos 1402 were recovered and there was no evidence of increased radioactivity in the areas where the pieces reentered. RORSAT launches did not resume until June 1984, a year and a half later. A second RORSAT was also launched in 1984.

F. MUTUAL NONINTERFERENCE WITH RECONNAISSANCE SATELLITES

For the time being at least, it remains in the Soviet interest not to interfere actively with U.S. satellite flights just as it is U.S. policy not to interfere with theirs. The SALT I agreement includes a provision for noninterference with "national technical means" of verification. The first visible threat to this reciprocity was a report in late 1975

that the Soviets had begun probing U.S. military satellites with powerful laser beams, but DOD later stated that Soviet gas pipeline fires accounted for the phenomenon of temporary saturation of these space-borne sensors. In February 1983, reports in the Western press suggested that at least one U.S. reconnaissance satellite mysteriously ceased functioning over the Soviet Union, implying some sort of hostile act. No confirmation or denial of this alleged incident was made by U.S. Government officials.

G. CONCERNS ABOUT THE MILITARIZATION OF SPACE AND "STAR WARS"

In the early 1980's, concern began to grow about the apparent "militarization" of space, that is, the increasing use of space for military purposes, particularly weapons. As noted above, the 1978-79 negotiations initiated by President Carter and aimed at developing a treaty to ban weapons from space were unsuccessful. In 1981, the Soviets introduced a draft treaty at the United Nations, but a close reading showed that it would ban only the stationing of weapons in space, and since neither the existing Soviet ASAT nor the U.S. system in development is stationed in space, the treaty would have had little impact. No negotiations were held on this text.

In March 1983, President Reagan made a nationally televised address in which he called for research into technologies that could defend the United States and its allies against ballistic missile attacks. His advisers stated that these systems could be based on the ground, or in space, leading the media to dub this the "Star Wars" speech. Concern about the militarization of space intensified following the President's address, even though no decision has been made to deploy weapons in space. The initiation of testing of the U.S. ASAT also heightened concerns about war in space.

In August 1983, the Soviets introduced a revised draft treaty at the U.N. which would ban the use of force in space, a much broader scope than the earlier draft, thereby prohibiting both ASAT and ballistic missile defense activities in orbit, although space-based BMD is already banned by the 1972 ABM Treaty.

From the Soviet perspective, the advent of the U.S. space shuttle has contributed to their concerns about U.S. military intentions in space. The 1981 Soviet draft treaty would have prohibited the deployment of weapons, inter alia, on "piloted space vessels of multiple use." The 1983 revision would ban the use of manned spacecraft for military purposes.

During 1984, the potential for U.S./Soviet negotiations on space weapons dominated the headlines for many months. On June 29, the Soviets formally offered to hold talks with the United States on space weapons beginning that September in Vienna. After several weeks of charges and countercharges that each side was setting unacceptable preconditions (the Soviets wanted the United States to agree to a moratorium on ASAT testing; the United States wanted the Soviets to agree to return to the negotiating table on offensive weapons), no talks were scheduled.

At the end of 1984, U.S. Secretary of State Schultz was preparing to meet with Soviet Foreign Minister Gromyko in Geneva, and it was expected that agreement would be reached on resuming the talks on offensive weapons (the INF and START negotiations) and beginning space weapons talks.

CHAPTER SIX: SUPPORTING RESOURCES FOR SPACE FLIGHT

A country's ability to routinely place satellites in orbit depends on supporting resources within that country, including funding, manpower, laboratories and factories, launch sites, tracking facilities, and launch vehicles. To the extent that information is available, these supporting resources are discussed in this section.

A. SPACE EXPENDITURES OF THE U.S. AND U.S.S.R.

The United States, between FY59 and FY84, had spent about $184 billion on the space program in the several agencies of Government involved. In fiscal year 1985, these expenditures should be about $22 billion ($7.2 billion for NASA, $13 billion for DOD, the rest for other agencies). At its peak, the United States was spending close to one percent of its gross national product on space, and today it is spending about one-third of one percent. (These are current dollars unadjusted for inflation.)

The Soviet Union does not publish space budget data. Because the Soviets fly a greater weight of hardware, one could assume that their program is at least of the same magnitude as that of the United States at its former peak, and may be larger. In 1982, a U.S. Government estimate was made suggesting that the Soviets spent $18 billion in 1982 (or about 50 percent more than the $13 billion spent in the United States) on its space program. The 1984 edition of DOD's Soviet Military Power, estimated that the Soviets would spend $22 billion on their space program in 1985, but these figures did not include operations and maintenance.

International comparisons of this nature are notoriously difficult to make, and one should avoid the temptation to convert such crude estimates into ruble or dollar equivalents.

B. MANPOWER

In the United States, the National Aeronautics and Space Administration (NASA) program alone at its peak employed about 400,000 people (with 7 percent of these on the NASA payroll), but now has dropped to about 134,000. There were probably about 600,000 people at the peak employed in total U.S. space work. This figure does not include the indirect beneficiaries of the space program from the multiplier effects of these expenditures, nor does this figure emphasize the dependence of some regions upon space expenditures.

The Soviet Union does not disclose how many people are employed in its space work, but the space work force may be close to 600,000 people because their effort today seems to be at least equal to the 1966 U.S. peak.

C. SPACE LABORATORIES AND FACTORIES

The United States has several major NASA development centers, and other facilities operated by the Air Force and the Department of Energy. The private aerospace industry has a widespread industrial base capable of building and testing hardware.

The Soviet Union does not allow visits to many of its development facilities and no real measure of its total capacity is available in the public domain. Western observers are aware of the existence of many technical and scientific institutes, and have heard of a special space city in Kazakhstan (Leninsk perhaps) where it is believed major assembly work is done. There is no reason to believe the total Soviet aerospace industry is as fully equipped

as that of the United States, because of their tendency to do more testing in flight compared with the United States. On the other hand, missiles of somewhat similar capabilities, but with different design philosophies, appearing in Moscow parades suggest the existence of more than one design and development team for space work just as in Soviet aviation. Early in 1979, reports circulated that there are five design bureaus for missiles and launch vehicles alone.

D. LAUNCH SITES

The United States has its major launch site for manned, lunar, planetary, and communications satellites at Cape Canaveral, Florida. It has a second launch site at Vandenberg Air Force Base, California, for satellites which must go into polar orbits (primarily weather, Earth resources, navigation, and reconnaissance). A third minor site for small payloads is at Wallops Island, Virginia. Short-range vertical testing also is done at White Sands, New Mexico.

The Soviet Union has developed launch sites very similar to the United States. The major site for manned, lunar, planetary, and some communications satellites, plus other developmental work, is near Tyuratam and Leninsk in Kazakhstan. The Soviets call it the Baykonur Cosmodrome, but it is about 370 kilometers from the town of Baykonur. A second, largely military operational site, but also used for navigation, communication, and weather satellites, is near Plesetsk in the arctic. The third site is more modest, and is located near Kapustin Yar from which launches of vertical probes (like White Sands) and small orbital payloads (like Wallops Island) are made.

Table 7 summarizes the number of launch successes and resulting payloads from all launch sites in the world.

TABLE 7. Summary of World-Wide Successful Space Launches by Site 1957-1984

Launch Site	1984	1957-1983	Total
Plesetsk (U.S.S.R.)	62	931	993
Tyuratam (U.S.S.R.)	33	626	659
Vandenberg AFB (U.S.)	10	452	462
Cape Canaveral (U.S.)	12	344	356
Kapustin Yar (U.S.S.R.)	2	79	81
Wallops Island (U.S.)	0	18	18
Kourou (Guyana)	4	11	15
Uchinoura (Japan)	1	13	14
Tanegashima (Japan)	2	11	13
Shuang Cheng-tzu (China)	1	11	12
Indian Ocean Platform (Kenya)	0	8	8
Hammaguir (Algeria)	0	4	4
Sriharikota (India)	0	3	3
Woomera (Australia)	0	2	2
Chengdu (China)	2	0	2
TOTAL	129	 2,513	 2,642

E. TRACKING FACILITIES

As an outgrowth of the IGY period, the United States created a worldwide tracking system with the cooperation of many other countries. This was upgraded to meet the needs of Apollo as well as other programs. For U.S. deep space missions, there are large 34- or 64-meter diameter dish antennas in California, Australia, and Spain which supported the lunar portion of Apollo and distant planetary flights. Even with all these facilities, the U.S. tracking system has had to be supplemented with tracking ships and special electronic-systems aircraft working in conjunction with satellites used to relay data on a real-time basis. NASA's Tracking and Data Relay Satellite System (TDRSS) will perform most of these functions in the future. The first TDRS was launched in 1983; two more are scheduled for 1985.

The Soviet Union claims to have a nationwide tracking system, and the great expanse of their country gives them a good start without leaving their own territory. There have been occasional reports of Soviet efforts to place some tracking facilities in Africa and Cuba. Their principal deep space tracking facility is in the Crimea. The Soviet Union relies on ships to fill in gaps and eleven ships have been identified as having been assigned to the Soviet Academy of Sciences for space work, and often these are described as scattered around the world for space support purposes. Other tracking ships, not identified as under Academy control, have been pictured in the press and seem to be associated primarily with military missile tests, but could support space work as well. For support of manned flights, one ship typically anchors off Nova Scotia. Soviet Molniya satellites relay information between tracking ships and the U.S.S.R. In 1982, the Soviets filed plans with the International Telecommunication Union for a satellite system which appears to be very similar to the U.S. TDRSS. When such a system might be launched is unknown.

F. LAUNCH VEHICLES

The United States has used launch vehicles scaled to lift payloads from as light as 9 kilograms up to the Saturn V which could carry over 136,000 kilograms to low Earth orbit. In its manned programs, the Mercury spaceship (weighing about 1,360 kilograms) was launched to orbit by Atlas. The Gemini (weighing about 3,630 kilograms) was launched by Titan II. Several Earth orbital Apollo flights, weighing about 20,410 kilograms, were launched by the Saturn IB. The lunar Apollos, launched by Saturn V, weighed about 52,600 kilograms in the vicinity of the Moon. (For any launch vehicle, the farther the orbit is from the Earth, the greater the velocity required to get

there and the smaller the payload. This is why Saturn V carried much less to the Moon than to Earth orbit.)

In 1957 the Soviet Union started to use its original ICBM, with an orbital lift capacity of 1,360 kilograms. The same basic "A" vehicle is in use today with upper stages added to improve performance. These upper stages permitted the launch of about 450 kilograms to the Moon in the first Luna series, and about 1,500 kilograms in the second Luna series. The early Luna-type launch rocket also was able to put up Vostok manned craft of 4,700 kilograms. The weight of Soyuz T, a modified Soyuz which entered service in 1980, is about 7,000 kilograms, and still uses the same basic launch vehicle with improved staging. The Proton or "D" launch vehicle has been demonstrated to carry 20,000 kilograms to Earth orbit. Its circumlunar capacity should be on the order of 4,820 kilograms and can send 4,650 kilograms to Mars. The "D" vehicle is the largest in the Soviet family of launch vehicles.

Table 8 summarizes world-wide use of basic vehicles for successful launches to Earth orbit and beyond.

TABLE 8. World-Wide Summary of Successful Launches by Basic First Stage, 1957-1984

Name	Country	Vehicle Origin	1984	1957-1983	Total
Sapwood (A)	USSR	missile (SS-6)	46	969	1015
Delta (Thor)	USA	missile	4	375	379
Skean (C)	USSR	missile (SS-5)	18	289	307
Atlas	USA	missile	5	191	196
Scarp (F)	USSR	missile (SS-9)	20	141	161
Titan	USA	missile	7	138	145
Sandal (B)	USSR	missile (SS-4)	0	144	144
Proton (D)	USSR		13	93	106
Scout	USA		1	73	74
Space Shuttle	USA		5	9	14
Saturn 5	USA		0	13	13
Saturn 1	USA		0	13	13
Mu	Japan		1	12	13
"N"	Japan	missile (Thor)	2	11	13
FB-1	China	missile (CSS-X4)	1	9	10
Ariane	ESA		4	5	9
Diamant B	France		0	6	6
Redstone	USA	missile	0	4	4
Jupiter	USA	missile	0	4	4
Diamant	France		0	4	4
Vanguard	USA		0	3	3
SLV-3	India		0	3	3
Long March 1	China	missile (CSS-2)	0	2	2
Long March 3	China		2	0	2
Lambda	Japan		0	1	1
Black Arrow	U.K.		0	1	1
Total.....			129	2,513	2,642

By Soviet accounts, several of their launch vehicles use liquid oxygen and a kerosene derivative for the first stages (as do many of those of the United States), and use fairly conventional storable fuels for upper stages. They do not, however, use the high efficiency dual cryogenic fuel (liquid hydrogen/liquid oxygen), used in U.S. launch vehicles such as the Saturn V and space shuttle, the European Ariane, and China's Long March 3.

The United States has developed solid-fuel rockets mostly for military missile purposes, and certain space upper stages. The small Scout rocket is

solid fuel in all stages, and strap-on boosters using solid fuel are used with Titan variants and the space shuttle. There is no evidence that the Soviets use solid-fuel boosters in their space program, although they may have some for missile use.

The United States experimented with components for a nuclear rocket as an upper stage for Saturn. A solid core reactor would heat hydrogen to be expelled from the nozzle. The work was cancelled because of budgetary constraints and the lack of missions for which such propulsion would be needed. The Soviet Union could be developing a nuclear rocket, but so little has been said to date by them in this regard that any opinion on the subject would be highly speculative.

Looking at the upper range of national capabilities, the Saturn V clearly has been the most capable launch vehicle developed so far. As mentioned earlier, the Soviets have never successfully introduced an equivalent launch vehicle, although the U.S. Department of Defense reports that such a booster is in development.

The two major questions are when these new vehicles will be introduced, and what type of fuel they will use. At the end of 1984, reports were circulating in the trade press that a test launch of one or both of the vehicles was imminent, but the same rumors had been rampant at the end of 1983 and no tests were conducted in 1984. Either of these vehicles theoretically could signal a change to dual cryogenic fuels, but it is more likely that they would begin with upper stages rather than attempting to build an entire new launch vehicle using an untested (for them) fuel.

CHAPTER SEVEN: FUTURE DIRECTIONS FOR THE SPACE PROGRAMS

Attempting to predict the future of the space program is a difficult assignment as it depends upon political decisions as much as on technical capabilities. At least there are more engineering possibilities than there are financial resources likely to be made available to pursue them.

Estimating what the Soviet Union will elect to do in space is difficult for a Western observer because of Soviet secrecy. It is also difficult in the United States because even though there are many paper plans, they remain on paper until the President and the Congress agree on funding. The Soviets have stateed very long term goals (such as colonizing other planets), but have not elaborated on time frames. They, too, undoubtedly have to face hard budget choices before actual hardware work can begin.

A. REUSABLE SPACE VEHICLES

The existing U.S. space shuttle is seen only as the first of an evolutionary series of manned and unmanned reusable space vehicles. One concept under study at the present time is called SRB-X or SDLV (Shuttle Derived Launch Vehicle) which would be an unmanned derivative of the shuttle for lifting very heavy payloads into orbit.

The U.S. Air Force is also studying the possibility of developing a transatmospheric vehicle (TAV), which would be a smaller version of the space shuttle and capable of being launched in a shorter period of time from many different sites around the world. The TAV could be launched from a rocket sled on the ground, an inclined launch pad, or an aircraft

for a variety of purposes including reconnaissance and satellite inspection and repair. There also are concepts for space cruisers which could be deployed from the cargo bay of the space shuttle for sortie missions.

As noted in Chapter 2, the Soviets appear to be developing two reusable vehicles, one like the U.S. shuttle, and a smaller version called a spaceplane that may be similar in mission to the TAV and/or space cruiser.

B. MANNED SPACE STATIONS

By the end of 1984, the United States had orbited one space station (Skylab) which was occupied for parts of 1973 and 1974. The Soviet Union had successfully orbited six (plus two others which did not function once in orbit), the first of which entered service in 1971. The longest duration U.S. mission had been 84 days, compared with a new record of 237 days set by a three-man Soviet crew on Salyut 7 during 1984.

In his 1984 State of the Union address, President Reagan directed NASA to develop a permanent manned presence in orbit (meaning a space station) within a decade, and although funding for the program is controversial because of other budget priorities, NASA is proceeding with plans to initiate Phase B studies in 1985 with the goal of establishing an initial operational capability in 1992, the 500th anniversary of Columbus' founding of America. The reference design NASA has chosen for its initial space station includes one occupied module and two automated platforms. The occupied module and one platform would be co-located in a due-East orbit out of Cape Canaveral (at 28.5° inclination and approximately 500 kilometers altitude), while the other platform would be in a polar orbit. NASA expects that the space station and associated platforms wil be used for a wide range of scientific and commercial space projects, including astronomical observatories, remote

sensing activities, and manufacturing of very pure pharmaceuticals and crystals. The Department of Defense states that it has no mission requirements for a space station that cannot be conducted less expensively and just as effectively on unmanned spacecraft, but has also commented that it may became a paying user of the space station in the future.

The Soviet Union has a substantial lead over the United States in terms of experience in using crews on board space stations. They have an advantange in learning what tasks are particularly well suited to automation and which need to be performed by humans.

For the future, the Soviets speak confidently of building a large and permanent orbital station for many people, for the purpose both of conducting Earth applications work and scientific observations, and serving as an orbital assembly, checkout, and launch facility to send manned expeditions to the Moon and planets. Academician Keldysh, then President of the Soviet Academy of Sciences, predicted in October 1969 that such a large station might be ten years away, but would more likely be available in five years. By the end of 1984, it still had not been launched.

Current speculation in the West suggests that the next phase in the Soviet space station program will involve launch of a large core with four to six docking ports to which Salyut, Soyuz, and Kosmos 1443-type modules will be docked, and that a Saturn V-class launch vehicle is required to launch the core. If true, then it may be some time before the Soviets can accomplish this goal.

A November 28, 1983 article in Pravda outlined Soviet space station goals beyond those described by Keldysh. The article, by President of the Ukraininan Academy of Sciences B. Baton and Soviet Doctor of Technical Sciences Y. Semenov, described a complex of installations in altitudes

ranging from 200 to 4,000 kilometers linked to Earth by freight and passenger transport spacecraft. The complex would have specialized modules for scientific research, living quarters, power generation, refueling, repair workshops, and construction sites for producing and installing standardized construction components. No time frame was given for when such a complex might begin to be established.

While there is considerable discussion in the media and among aerospace professionals about the potential for space colonies, there are no firm plans for such an endeavor at this time. A popular scenario calls for construction of a 10,000 person colony at a Lagrangian point, where the gravitational forces of the Earth and Moon cancel each other out. This is often called the L-5 proposal, denoting one of the five Lagrange coordinates in the Earth-Moon system.

C. PROSPECTS FOR FUTURE MANNED FLIGHTS TO THE MOON

Following the six successful Apollo landings on the Moon, U.S. interest in continuing the program waned to the point that three additional landings (Apollo 18-20) were cancelled. In addition, there have been no U.S. unmanned lunar flights since the Apollo era. The Soviet Union, after losing the Moon race to the United States, continued unmanned Luna missions until 1976. Since that time, however, there has been little discussion of Soviet lunar plans.

In the United States, there is a growing amount of discussion by Government officials and interested observers about the possibility of establishing a lunar base. Some proponents prefer an international scientific facility, while others are promoting the potential of mining the Moon (and perhaps the asteriods) for raw materials which could be

used for space colonies and space stations in Earth orbit. A conference on the lunar base initiative was held at the U.S. National Academy of Sciences in October 1984, and although there are no existing plans to proceed with such a project, high ranking officials such as the President's Science Adviser have publicly endorsed the lunar base concept as an appropriate long range goal.

As for the Soviet Union, it would not be unexpected to see them send crews to the Moon eventually, since their goals in space are so broad and long range. If Western analysts are correct that the Soviets lost the Moon race because they did not have hardware capable of accomplishing the task, then the attempt might be made once hardware (for example the Saturn V-class booster and high energy upper stages) becomes available.

D. PROSPECTS FOR MANNED FLIGHTS TO THE PLANETS

U.S. and Soviet proposals for sending people to Mars are summarized in CRS Report 84-154, Mars: The Next Destination for Manned Space Flight? Briefly, both countries have been discussing manned flights to the planets for many decades. None of these plans has materialized into an actual program, although in recent years the level of discussion has intensified in both countries. In 1984, the prospect of a joint U.S./Soviet manned flight to Mars as an alternative to an "arms race in space" was introduced at hearings by the Senate Foreign Relations Committee on a resolution introduced by Senator Matsunaga. The resolution (S. J. Res. 236) was enacted into law (P.L. 98-562), but called primarily for a resumption of the U.S./Soviet agreement for space cooperation in general (see next section).

The Soviet Union has spoken more positively about manned flight to the planets and it is hard to doubt their ultimate intentions in this

regard if one studies their total program effort. Carrying out such flights will confront them with the same technical and financial questions which the United States would face. Nevertheless, they have frequently stated that one of the reasons they are extending the duration of manned missions in Earth orbit is to obtain data on human reaction to spaceflight conditions so someday they can send men to Mars (although they have never said they would land them on the planet). On October 18, 1984, at the end of the record setting 237 day flight on Salyut 7, the Soviet press agency TASS directly tied that duration to the length of time it would take to send a crew to Mars. Also, President of the Soviet Academy of Sciences Anatoliy Alexandrov stated on November 2, 1984 that sending people to Mars was technically feasible already, but that problems involving logistics (food, water, and fuel supply) had to be overcome. Roald Sagdeyev, head of the Institute of Space Research in the Soviet Academy of Sciences has been repeatedly quoted as saying that manned missions to the Moon and Mars will not occur before the year 2000.

E. COOPERATION BETWEEN THE UNITED STATES AND SOVIET UNION

While the main feature of the relationship between the United States and Soviet Union in space has been competition, the two countries have also cooperated throughout the years as well. The most long-standing and successful cooperative arrangements have involved the exchange of scientific data from planetary programs and on space biology. The Soviets have launched four biosatellite missions (in 1975, 1977, 1979, and 1983 respectively) which have carried U.S. experiments. Five major treaties concerning space activities have been negotiated at the United Nations and four have been signed by both countries (the fifth, called the Moon Treaty, has not been signed by either).

The future of U.S./Soviet cooperation has been clouded by international tensions. After the imposition of martial law in Poland in late 1981, President Reagan announced sanctions against the Soviet Union for the role it is believed to have played in that situation. Among the actions taken by Reagan was the announcement that the United States would not renew scientific agreements with the Soviet Union, including the space cooperation agreement which expired in May 1982. Two projects (the biosatellite mission launched in 1983 and the KOSPAS/SARSAT search and rescue satellite program) which were begun while the agreement was in force were continued, however, and both countries are cooperating with the European Space Agency and Japan in groundand space-based studies of Halley's Comet.

In 1984, Congress passed and the President signed a resolution (S. J. Res. 236, P.L. 98-562) calling for establishment of a new agreement between the United States and Soviet Union for cooperation in space as an alternative to an arms race in space. Also, in June, 1984, President Reagan announced that he would try to reach agreement with the Soviets on a joint space rescue mission that would involve a simulated mission between the U.S. space shuttle and the Soviet Salyut space station to demonstrate the ability of each side to rescue the other's space crews. At the end of 1984, the Soviets had not responded either negatively or positively to the suggestion.

F. POLICY ISSUES FOR THE 1980s

The overall space policy of the United States is embodied in the 1958 National Aeronautics and Space Act. Through the 1960s, the country focussed its efforts on meeting the 1961 goal established by President Kennedy to land men on the Moon by the end of the decade. A "Space Task Group", chaired

by then Vice President Agnew, issued recommendations in 1969 on goals for the U.S. space program following completion of the Apollo program. Reusable space vehicles, space stations, and manned journeys to Mars were included in the STG's report, but only the reusable space shuttle program was approved by the Nixon Administration.

In 1978, President Carter issued two space policy directives in an attempt to give guidance to the U.S. space effort, but they were subsequently criticized for not proposing specific programs. Congress responded with the introduction of several bills to specify programs which could be accomplished in the next 10 to 30 years, but none was reported from committee.

A proposal to build solar power satellites to meet energy shortages caused by high oil prices and limits to available fossil fuels attracted some interest from 1977-1981. Large solar arrays in geostationary orbit would collect sunlight and convert it to electricity for transmission to Earth. Industrial groups pushed energetically for demonstration projects, if not full scale development, while environmentalists raised many questions about side effects, and other analysts questioned the cost/benefit potentials. Government studies completed in 1980 and 1981 explored these issues, but did not resolve them. No funding has been provided for development of this concept since 1981.

President Reagan issued his own space policy on July 4, 1982. The directive reiterated U.S. policy to maintain separate military and civil space programs, but was criticized for seeming to place more emphasis on military space activities than those of the civilian and commercial sectors. Reagan's decision to initiate development of a space station for NASA in 1984 quieted some of these concerns, however. He has also issued several other policy directives concerning space, especially concerning the potential

for the commercialization of space, and a National Space Strategy which implements his several space policies.

In 1984, Congress directed that a National Commission on Space be established to look at the future of the U.S. space program and set goals for the next 20 years. The language required that the Commission be established by October 1984, and President Reagan issued an Executive Order creating the Commission in accordance with that language. The members of the Commission, who are to be chosen by the President, had not been named by the end of 1984, however. Since Congress gave the Commission only one year to deliberate, the longer it takes for the members to be named, the shorter the time they will have for considering all the options.

The Administration and the Congress will face difficult and perplexing choices related to space missions and the level of activity which is appropriate. The decisions will be made more difficult by lack of accepted facts as to the current, intermediate, and long term payoffs in economic benefits, national defense, and understanding of nature, on which human well-being may depend. In the area of space science, a backlog of projects suggested by advisory panels remains unfunded, and the long standing debate about whether people are needed to explore space or if automated devices can accomplish the task more cheaply continues.

The growing debate over the "militarization" of space may well be the most controversial of the decade, however. In FY82, space expenditures in DOD surpassed NASA's space budget for the first time and for FY85, DOD received approximately $13 billion for its space activities, compared to approximately $7.5 billion for NASA (including aeronautics). The DOD space budget would be even larger if NASA-funded development of the space shuttle was taken into account.

There are a number of specific issues that will have to be dealt with in the remainder of this decade, including operation of the space shuttle (as a research and development agency, NASA is not expected to be the operator of the shuttle system once it is completely developed), and the continued interaction between NASA and DOD, particularly in the development of launch vehicles. A major controversy developed in 1984 over DOD's decision to retain ten expendable launch vehicles (ELVs) beyond the time that it was supposed to have completely transitioned to use of the shuttle. DOD argued that the shuttle was not flexible enough to provide "assured access to space." Although Congress approved procurement of an additional 10 launch vehicles, it directed that NASA and DOD work together to determine U.S. launch vehicle need in the years ahead, and made it clear that DOD would encounter great difficulty if it decided it wanted more than ten ELVs.

Other issues are certain to arise as the commercialization of space steps into full swing. Already, the President has identified a series of proposals to clarify the tax code and tariff and trade requirements related to products made in space to encourage companies to invest in space activities. Because of the failure of three communications satellites in 1984, insurance rates for satellite owners rose substantially, and the Government may also have to consider the possibility of becoming an "insurer of last resort" to enable companies to get involved in the use of space.

CHAPTER EIGHT: TABLE OF SPACE "FIRSTS" -- U.S. AND SOVIET

Any attempt in simple form to compare the relative pace of the two principal space programs through a table of firsts has certain weaknesses, as it does not answer by how many days or years a particular event occurred in one country before another. Further, it does not distinguish between a nominal first accomplishment in crude form by one country, sometimes followed by a much more impressive and elaborate follow-up by the other country. Nonetheless, such firsts do affect public opinion, and analysis by various fields of endeavor may give some sense of relative direction of pacing efforts in each country. Table 9 attempts such a measure.

TABLE 9. Major U.S. and Soviet Space "Firsts"

United States			Union of Soviet Socialist Republics		
Event	Satellite	Launch Date	Event	Satellite	Launch Date
Bio and Manned Flight			**Bio and Manned Flight**		
Manned orbital maneuver	Gemini 3	03/23/65	Animal in space (dog)	Sputnik 2	11/03/57
Controlled extravehicular activity	Gemini 4	06/03/65	Animal in space, recovered	Korabl Sputnik 2	08/19/60
Manned space rendezvous	Gemini 6, 7	12/04/65	Man in space, recovered	Vostok 1	04/12/61
Manned docking with unmanned vehicle	Gemini 8-Agena	03/16/66	Multi-manned spacecraft	Voskhod 1	10/12/64
Manned lunar orbit	Apollo 8	12/21/68	Extravehicular activity	Voskhod 2	03/18/65
Manned lunar return reentry	Apollo 8	12/21/68	Recovery, circumlunar live animals	Zond 5	09/21/68
Lunar orbit rendezvous	Apollo 10	05/18/69	Manned docking with another manned ship	Soyuz 4-5	1/14/69
Lunar landing and return	Apollo 11	07/16/69	18-day flight	Soyuz 9	06/01/70
Lunar pinpoint landing	Apollo 12	11/14/69	Space station	Salyut 1	04/19/71
Manned lunar rover	Apollo 15	07/26/71	24-day flight	Soyuz 11	06/06/71
28-day flight	Skylab 2	05/25/73	International docking	Soyuz 19	07/15/75
59-day flight	Skylab 3	07/28/73	2 ferry craft docked to station	Soyuz 26/27	01/10/78
84-day flight	Skylab 4	11/16/73	96-day flight	Soyuz 26/27	12/10/78
International docking	Apollo	07/15/75	International crew launch	Soyuz 2	03/02/78
Flight of reusable vehicle	STS 1	04/12/81	140-day flight	Soyuz 29/31	06/15/78
4-person crew	STS 5	11/11/82	175-day flight	Soyuz 32/34	02/25/79
5-person crew	STS 7	06/18/83	185-day flight	Soyuz 35/37	04/09/80
6-person crew	STS 9	11/28/83	211-day flight	Soyuz T-5/T-7	05/13/82
Untethered EVA	STS 41-B	02/03/84	Construction in space	Soyuz T-9	06/27/83
In-orbit satellite repair	STS 41-C	04/06/84	237-day flight	Soyuz T-10/11	02/08/84
7-person crew	STS 41-G	10/05/84	Woman EVA	Soyuz 12	07/17/84
Satellite retrieval/return	STS 51-A	11/08/84			

TABLE 9. Major U.S. and Soviet Space "Firsts"--continued

United States			Union of Soviet Socialist Republics		
Event	Satellite	Launch Date	Event	Satellite	Launch Date
Civil and Military Applications			**Civil and Military Applications**		
Active communications	Score	12/18/58	Domestic communications	Molniya 1-1	04/23/65
TV pictures from space	Explorer 6	08/07/59	Fractional orbit bombardment	Kosmos 139	01/25/67
Weather satellite	Tiros 1	04/01/60	Co-orbital antisatellite test	Kosmos 248 & 249	10/20/68
Navigation satellite	Transit 1B	04/13/60	Radar ocean surveillance	Kosmos 626?	12/29/73
Missile detection	Midas 2	05/24/60			
Observation recoverable flight	Discoverer 13	08/10/60			
Passive communications	Echo 1	08/12/60			
Operational synchronous communications	Syncom II	07/26/63			
Nuclear explosion detection	Vela Hotel	10/17/63			
Earth resources satellite	ERTS 1	07/23/72			
Synchronous 24-hour weather	SMS 1	05/17/74			
Commercial maritime communications	Marisat 1	02/19/76			
Ocean resources satellite	SeaSat 1	06/27/78			

TABLE 9. Major U.S. and Soviet Space "Firsts"--continued

United States			Union of Soviet Socialist Republics		
Event	Satellite	Launch Date	Event	Satellite	Launch Date
Science			**Science**		
Van Allen radiation belts	Explorer 1	02/01/58	Orbiting geophysical lab	Sputnik 3	05/15/58
Earth shape measured	Vanguard 1	03/17/58	Farside lunar picture	Luna 3	10/04/59
Orbiting solar observatory	OSO 1	03/07/62	Cosmic ray measurements	Proton 1	07/16/65
Data from Venus	Mariner 2	08/27/62	Pictures from lunar surface	Luna 9	01/31/66
Geodetic satellite	Anna 1B	10/31/62	Lunar surface bearing test	Luna 13	12/21/66
Lunar close-up pictures	Ranger 7	07/28/64	Venus atmospheric probe	Venera 4	06/12/67
Mars pictures	Mariner 4	11/28/64	Automated return of lunar sample	Luna 16	09/12/70
Micrometeorite satellite	Pegasus 1	02/16/65	Automated lunar roving laboratory	Luna 17	11/10/70
Lunar orbit pictures	Orbiter 1	08/10/66	Venus soil analysis	Venera 8	03/27/72
Lunar trenching	Surveyor 3	04/17/67	Venus surface pictures	Venera 9	06/08/75
Color picture of full Earth face	DODGE	07/01/67	Radio telescope 10-meter dish	Salyut 6	09/29/77
Lunar soil chemical analysis	Surveyor 5	09/08/67			
Point-stabilized Orbiting Astro-Observatory	OAO 2	12/07/68			
Live lunar TV broadcast	Apollo 8	12/21/68			
Return of lunar rocks	Apollo 11	07/16/69			
Long life lunar surface sensors	Apollo 12	11/14/69			
Color pictures of Jupiter	Pioneer 10	03/03/72			
Color pictures of Saturn	Pioneer 11	04/06/73			
Radiotelescope, far side Moon	Explorer 49	06/10/73			
Pictures of Venus	Mariner 10	11/03/73			
Pictures of Mercury	Mariner 10	11/03/73			
Solar Probe	Helios 1	12/10/74			
Mars surface pictures	Viking 1	08/22/75			
High energy astro observatory	HEAO 1	08/12/77			
Detailed Jupiter Moons surveys	Voyager 1	09/05/77			
Detailed Saturn Moons surveys	Voyager 1	09/05/77			

TABLE 9. Major U.S. and Soviet Space "Firsts"--continued

United States			Union of Soviet Socialist Republics		
Event	Satellite	Launch Date	Event	Satellite	Launch Date
Space Flight and Propulsion			**Space Flight and Propulsion**		
Multiple spacecraft payload	Transit/ Solrad	06/22/60	Space flight	Sputnik 1	10/04/57
Payload recovery	Discoverer 13	08/10/60	Earth escape spacecraft	Luna 1	01/02/59
			Lunar impact	Luna 2	09/12/59
Hydrogen rocket orbited	Centaur 2	11/27/63	Orbital platform launch	Sputnik 5	02/12/61
Docked spacecraft maneuver	Gemini 10-Agena	07/18/66	Venus flyby	Venera 1	02/12/61
			Mars flyby	Mars 1	11/02/62
Lunar-velocity reentry	Apollo 4	11/09/67	Venus impact	Venera 3	11/16/65
Constant deceleration reentry	Apollo 8	12/21/68	Lunar soft landing	Luna 9	01/31/66
			Lunar orbiter	Luna 10	03/31/66
Mars orbit	Mariner 9	05/30/71	Automatic docking	Kosmos 186/188	10/27-29/67
Jupiter flyby	Pioneer 10	03/03/72			
Solar system escape	Pioneer 10	03/03/72	Recovery, lunar payload	Zond 5	09/21/68
Venus/Mercury flyby	Pioneer 10	11/03/73	Skip reentry lunar payload	Zond 6	11/10/68
Jupiter/Saturn flyby	Pioneer 11	04/05/73			
Libration point halo orbit	ISEE 3	08/12/78	Venus soft landing	Venera 7	07/17/70
			Mars impact	Mars 2	05/19/71
			Mars soft landing	Mars 3	05/28/71
			Venus orbit	Venera 9	06/18/75
			Automatic propellant transfer	Progress 1	01/20/78
Auxiliary Power Systems			**Auxiliary Power Systems**		
Solar cells	Vanguard 1	03/17/58	Battery power	Sputnik 1	10/04/57
Isotope power	Transit 4A	06/29/61			
Nuclear reactor in orbit	Snapshot 1	04/03/65			
Fuel cell	Gemini 5	08/21/65			

PART TWO

SPACE ACTIVITIES OF OTHER LAUNCHING COUNTRIES/ORGANIZATIONS

For the first two decades of the space program, the United States and Soviet Union clearly dominated space activities. While they still are responsible for the vast majority of space launches today, the 1980s are witnessing the emergence of at least four additional launching countries/organizations: China, the European Space Agency (a group of eleven European nations), India, and Japan.

Four other countries--Australia, France, Italy, and the United Kingdom--are sometimes counted as launcher countries, but are not included here. Australia and Italy have both operated launch facilities, although the Australian site (Woomera) is now closed. In addition, Australia launched its own satellite, Wresat, in 1967. Since a U.S. rocket was used for the launch and no other Australian launches have been made, it is not counted here as a launcher country. Italy's facility (the San Marco Platform off the coast of Kenya) is still used, and Italy has launched four of its own satellites, but these also have used U.S. launch vehicles, so Italy is not counted as a launching country.

France and the United Kingdom did develop their own launch vehicles. The French Diamant successfully placed 12 payloads in orbit from 1965 to 1975, but was then phased out of service. The British Black Arrow successfully placed one satellite (Prospero) in orbit in 1971, but was never used again for space launches. Since their indigenous launch vehicles are no longer in use, neither country is included here as a separate launching country,

although both are now members of the European Space Agency (ESA) which developed the Ariane launcher, and its activities are discussed.

A number of countries other than the United States and Soviet Union have significant national space programs, including several European countries that also participate in space activities as members of ESA. These activities are discussed in CRS Report 84-127, Space Activities of the Non-Launching Countries.

CHAPTER ONE: CHINA

China launched its first satellite in 1970. By the end of 1984, it had made a total of 14 launches, placing 16 satellites into orbit. Of these, six spacecraft have been recovered, and are thought to be related to development of a reconnaissance satellite capability (recovery is necessary for film-type reconnaissance satellites). Several others were not recovered and their missions remain unclear. They could have had scientific missions or could have been related to a different type of reconnaissance capability (electronic intelligence, for example). One launch in 1981 which placed three spacecraft into orbit simultaneously was definitely for scientific purposes, and two in 1984 were for communications. Most have been launched from Shuang Cheng-tzu in the northern part of China (near Jiuquan), and are listed in Table 10.

In 1984, the Chinese introduced their new Long March 3 (CZ 3) launch vehicle, which has a cryogenic (liquid oxygen/liquid hydrogen) upper stage. It is only the third entity to use that type of high efficiency liquid fuel (after the United States and ESA). The vehicle was launched twice in 1984 and inaugurated use of a new launch site in the southeastern part of China. Although the Chinese have not released coordinates for the site, it is known to be in Chengdu province, and thus has been tentatively designated as Chengdu in this report. Analysis of the ground tracks from the Chinese satellites by the Kettering Group suggests that the site may be at approximately 28°N, 103°E near Hsi-ch'ang. Photographs released by the

Chinese show mountains in the background behind the launch pad which is consistent with the topography of that part of the country.

The first launch of the CZ-3, in January 1984, placed its payload into a relatively low orbit, after which it performed extensive maneuvers. There is dispute among Western observers as to whether the mission was only to test the new upper stage and succeeded, or if it was supposed to place its payload in geostationary orbit and failed. For this report, it is counted as a launch success, but a payload failure.

The April 1984 launch did place China's first indigenous communications satellite in geostationary orbit, and it appears to be functioning properly in its orbital location at 125°E. The third launch of 1984 came from Shuang Cheng-tzu and the payload was recovered, suggesting a reconnaissance role.

In addition to using its own communications satellite, China is a member of INTELSAT, and has six major communications satellite ground stations at Urumqi, Kunming, Beijing, Shijiazhuang, Nanjing, and Lhasa. At the 1982 UNISPACE'82 conference (U.N. Conference on the Exploration and Peaceful Uses of Outer Space), China announced that once it had the capability, it would launch communications satellites for other developing countries. It did not state whether or not it would charge for services. On September 20, 1984, Ren Xinmin, Chairman of the Committee for Scientific and Technology Work of China's Ministry of Astronautics Industry, averred that they were "now in a position to launch satellites for other countries."

The Chinese are purchasing a Landsat receiving station from the United States, which may also be able to receive data from the French SPOT Earth resources satellite, scheduled for launch in 1985.

In 1984, China signed three agreements for cooperation in space technology with the Federal Republic of Germany, Italy, and France, and reported that discussions are underway with Brazil. A report by Aviation Week and

Space Technology in October 1984 that the United States had signed an agreement with China for space cooperation was denied by NASA, which added that the two countries had established a working group to consider possible cooperative activities. The Chinese have indicated that they would like to fly an astronaut on the space shuttle, and put down earnest money for two space shuttle launches in 1988 for direct broadast satellites.

The Chinese made several revelations about their space program during 1984. For example they announced that they had flown a puppy in space in 1967. The puppy, named Xiao Bao (Little Leopard), apparently flew on a suborbital rocket and was successfully recovered. They also reported that there had been a major explosion at one of their launch pads on January 28, 1978 which resulted in at least seven people being seriously injured, and a dozen or more people receiving burns to their hair, eyebrows, and faces. In addition, they honored as a martyr a young engineer who helped develop the first geostationary satellite, but died after 6 or 7 years of suffering the health effects of exposure to radiation during experiments related to that task. Finally, they announced that they have outfitted two ships to provide tracking services for satellite launches.

It is extremely difficult to discuss the future of the Chinese space program, not only because they do not release very much information about their activities, but also because their plans change quite abruptly. During 1979 and 1980, they expressed great plans for utilization of space, and even had astronauts in training. In late 1980 and early 1981, however, they retreated from their expansive plans because of a reassessment of the Chinese economic situation. Agreements to purchase broadcasting satellites from the United States were cancelled, and they announced that their manned space program had been postponed for at least the remainder of the decade.

As noted above, however, they subsequently changed their mind and have signed an agreement with NASA for the launch of two direct broadcast satellites on the space shuttle in 1988, and the satellites will be imported (a contractor has not been selected). Whether their plans will change again before 1988 remains to be seen.

TABLE 10. CHINESE SPACE LAUNCHES 1970-1984

Spacecraft Name	Launch Date	Launch Site	Comments
China 1	04/24/70	SCt	Engineering test. "East is Red" song played until 05/20/70.
China 2	03/03/71	SCt	Housekeeping test and possible science.
China 3	07/26/75	SCt	Science? Reconnaissance? Not recovered.
China 4	11/26/75	SCt	Possible reconnaissance test. Recovered.
China 5	12/16/75	SCt	Like China 3.
China 6	08/30/76	SCt	Possible electronics intelligence gathering test and/or science. Not recovered.
China 7	12/07/76	SCt	Possible reconnaissance test. Recovered.
China 8	01/26/78	SCt	Possible reconnaissance test. Recovered.
China 9-11	09/19/81	SCt	Triple scientific payload for space physics experiments.
China 12	09/09/82	SCt	Possible reconnaissance test. Recovered.
China 13	08/19/83	SCt	Possible reconnaissance test. Recovered.
China 14	01/29/84	Chengdu	Possible failure of new upper stage.
China 15	04/08/84	Chengdu	First Chinese geostationary communications satellite.
China 16	09/12/84	SCt	Possible reconnaissance test. Recovered.

* SCt = Shuang Cheng-tzu

Source: Data from Chinese news bulletins; World-Wide Space Activities (House Science and Technology Committee, 1977); and P.S. Clark, The Chinese Space Programme, Journal of the British Interplanetary Society, v. 37, pp. 195-206, 1984.

CHAPTER TWO: EUROPEAN SPACE AGENCY AND ARIANESPACE

The European Space Agency (ESA) was formed in 1975 by the merger of the European Scientific Research Organization and the European Launcher Development Organization. It has eleven members (Belgium, Denmark, France, Federal Republic of Germany, Ireland, Italy, Netherlands, Spain, Sweden, Switzerland, and the United Kingdom) plus two associate members (Austria and Norway). ESA has a technical agreement of cooperation with Canada as well.

A major ESA activity has been development of an independent launch capability using a launch vehicle called Ariane (see Table 11). France played the lead role in developing Ariane, and the vehicle is launched from Kourou in French Guiana (South America). In addition, Arianespace, a private company which now markets Ariane and manages the launches, is incorporated in France. As a result, Ariane is often mistakenly referred to as a French launch vehicle.

Arianespace, as noted above, is now responsible for Ariane launches so it, rather than ESA, is the "launching country" included here. ESA will continue to upgrade Ariane performance, so is still involved in the launch vehicle effort, and its activities will continue to be included in this report.

Ariane is competing directly for commercial traffic with the U.S. space shuttle. Ariane can lift 1,780 kilograms into geostationary orbit, or two conventionally sized satellites, thereby reducing costs to the users. The Europeans also offer attractive financing plans where the user makes a relatively small down payment, and then does not have to pay the

balance until six months after launch when the satellite is producing revenue. By contrast, users must pay all costs in advance for launches via U.S. boosters. Arianespace has been successful in convincing several U.S. companies to use Ariane instead of U.S. vehicles.

The space shuttle is the only reusable space vehicle in the world. All the others, including Ariane, are called expendable launch vehicles (ELVs), and in the United States, it was expected that ELVs would be phased out once the shuttle was operational. Several companies are convinced, however, that there is still a need for ELVs, and Ariane's success demonstrates that some customers are quite happy using the older technology. Ariane's success has not only resulted in competition for space shuttle payloads, but also with those U.S. companies wishing to market the ELVs. One of them, Transpace Carriers Inc., filed a predatory pricing charge against Arianespace in 1984, alleging that Arianespace was unfairly subsidizing Ariane prices. Arianespace responded that the U.S. Government was unfairly subsidizing the space shuttle. The matter is now before the Office of the U.S. Trade Representative.

As noted above, ESA will continue to develop advanced versions of Ariane, and is currently discussing plans for the Ariane 5 which, in addition to being capable of placing 15,000 kilograms into low Earth orbit or 4,500 kilograms into geostationary orbit, would be reusable. According to the Europeans, this would make the system comparable to the U.S. space shuttle. France has proposed development of a small reusable manned vehicle called Hermes which could be launched on an Ariane 5, although ESA has indicated that it cannot afford Hermes at the current time. France has indicated that it may seek bi-lateral agreements for developing Hermes if ESA does not fund the program.

ESA's space activities encompass a broad range of science and applications satellites, and its programs have involved a considerable degree of cooperation with the United States. This cooperation has resulted in some discord, however, because of budget constraints within NASA which led to cancellation of the U.S. half of a joint project called the International Solar Polar Mission (ISPM). Originally, ISPM would have involved the launch of two probes to simultaneously study the north and south poles of the Sun. ESA and NASA would each have provided one spacecraft, and NASA would have supplied the power unit (a radioisotope thermal generator), launch, and tracking for both probes. In 1981, the United States unilaterally abrogated the memorandum of understanding with ESA on ISPM, prompting formal statements of displeasure from several ESA member countries to the U.S. State Department. Nevertheless, the mission could not be accommodated within NASA's budget, and the U.S. spacecraft was cancelled. NASA has kept its commitment to provide the power unit, launch, and tracking for the ESA spacecraft, however. The European probe has been renamed Ulysses and its launch is scheduled for 1986.

Relations between NASA and ESA have cooled slightly because of the ISPM incident, but it seems likely that the two agencies will continue to develop certain programs jointly. For example, ESA has agreed to participate in NASA's space station program, building on its experience with Spacelab, a scientific laboratory which is carried inside the cargo bay of the space shuttle, thereby providing a "shirt-sleeve" environment for performing a wide variety of experiments.

Spacelab was developed as a cooperative project with NASA during the 1970's. Spacelab pallets have also been developed by ESA for use outside the habitable module for those experiments which require exposure to the

space environment. The first Spacelab module was turned over to NASA in December 1981, and was launched in November 1983. The crew included an ESA astronaut, Ulf Merbold of West Germany, the first non-American to fly on an American manned mission. Two Spacelab flights are scheduled for 1985.

West Germany was the lead country in Spacelab development and, along with Italy, has proposed using Spacelab modules to form a European space station. Called Columbus, the concept may serve as the basis for plans to provide manned and unmanned modules which can be attached to or co-located with NASA's space station, which is expected to be operational in the early 1990's. The total cost for development, manufacture and utilization of Columbus modules and components is expected to be $2.12 billion over 7 years.

ESA is also developing a free-flying platform called Eureca (European Retrievable Carrier) as a follow-on to the Spacelab pallet. Eureca platforms will serve as a structure (or "bus") for providing power supply and orbit stabilization systems for payloads which can be placed on and later removed from it. The platform will be deployed from and retrieved by the U.S. space shuttle, and can accommodate 1000 kilograms of payload. The first payload will be five facilities for materials processing and life sciences experiments, and the Inter-Orbit Communications package for relaying data to the ground through a planned European communications satellite operating at 30/20 gigahertz.

Among ESA's other ongoing programs is the Giotto project to send a probe to intercept Halley's Comet when it returns to the Earth's vicinity in 1985-1986. A proposal to send a U.S. probe to the comet was dropped because of budget constraints, and ESA later rejected a NASA proposal for a joint ESA/NASA comet mission. Giotto is scheduled for launch on Ariane in 1985. The Soviet Union and Japan are also sending probes to Halley's

comet and an agreement between the three entities has been negotiated to provide for exchange of data from the missions. ESA also is developing an Earth orbiting astronomical observatory called Hipparchos for launch in 1986.

TABLE 11. EUROPEAN SPACE AGENCY/ARIANESPACE LAUNCHES 1979-1984*

CAT	Dec. 24, 1979	Success. First test launch. Carried CAT test package.
Firewheel Oscar 9	May 23, 1980	Failure. Second test launch. One scientific and one communications satellite lost.
Meteosat Apple	June 19, 1981	Success. Third test launch. Launched European weather satellite and experimental Indian satellite.
Marecs	Dec. 20, 1981	Success. Fourth and final test launch.
Marecs B Sirio 2	Sept. 9, 1982	Failure. First operational launch. Two communications satellites lost.
ECS Oscar 10	June 16, 1983	Success. Placed two communications satellites in orbit.
Intelsat	Oct. 19, 1983	Success. Communications satellite.
Intelsat	March 5, 1984	Success. Communications satellite.
GTE Spacenet	May 22, 1984	Success. Communications satellite. First launch operations by Arianespace.
ECS-2 Telecom 1A	Aug. 4, 1984	Success. Two communications satellites.
GTE Spacenet Marecs B2	Nov. 9, 1984	Success. Two communications satellites.

* All launches are from Kourou, French Guiana (South America). Information taken from Aviation Week and Space Technology, Flight International, Aerospace Daily and other trade publications.

CHAPTER THREE: INDIA

India has been involved in developing satellites and launch vehicles for many years. Its first satellite, Aryabhata, was launched by the Soviet Union in 1975. While cooperation with the Soviets has continued (they launched two remote sensing satellites, Bhaskara 1 and 2, for the Indians in 1979 and 1981 respectively), India has also pursued development of an independent launching capability. The Indian Space Research Organization (ISRO) is the primary Government space agency in India, and is based in Bangalore. Launches are made from Sriharikota at the southern tip of India.

The first test launch of the Indian booster SLV-3 failed in August 1979. The Indians achieved success with their second test launch on July 18, 1980, however, which placed the Indian satellite Rohini 1 into Earth orbit (it remained in orbit until July 1981, longer than expected). The third SLV-3 flight took place on May 31, 1981, and although it succeeded in placing Rohini 2 into orbit, the altitude was lower than planned and the satellite decayed after only 9 days (instead of the expected 300 days). These Rohini satellites are primarily for monitoring the performance of the launch vehicle, although Rohini 2 also carried remote sensing equipment. On April 17, 1983, the Indians orbited Rohini 3 and announced it was for Earth resources studies. Some Western sources have suggested that the Indians are attempting to develop a military reconnaissance capability. No launches were made by India in 1984.

The Indians developed a communications satellite, APPLE, which was launched on the third Ariane test flight in June 1981. One of the solar

panels did not deploy properly, but the satellite operated with reduced power for two years. In April 1982, the United States launched INSAT 1A for the Indians. The satellite had three functions: meteorology, voice and data transmissions, and direct broadcast transmissions. Several problems developed with the satellite once it was in orbit (the solar sail did not deploy at all, and the C-band antenna would not deploy for several weeks), and by September its fuel supply (which should have lasted for many years) was exhausted, apparently because an open valve allowed the fuel to escape. The back-up satellite, INSAT 1B, was launched by the space shuttle in 1983 and is operating correctly. In 1984, India signed a launch agreement with the United States for INSAT 1C, which is scheduled for launch on the space shuttle in 1986.

Western press reports have indicated that India plans to spend $500 million on space activities between 1985 and 1990. The focus of the Indian space program is development of launch vehicles, and communications, remote sensing, and meteorological satellites.

In April 1984, an Indian military pilot, Rakesh Sharma, flew into space on Soyuz T-11 with two Soviet cosmonauts and docked with the Salyut 7 space station, which was already occupied by three other cosmonauts. Sharma remained on board the space station for seven days, participating in a variety of experiments including performing yoga to determine if special muscle relaxation techniques would help overcome the temporary physiological effects of weightlessness. The Indians also plan to send a scientist into space on the U.S. space shuttle mission that launches INSAT 1C in 1986.

CHAPTER FOUR: JAPAN

Over the past several years, Japan has released space program plans for the future which involve a very ambitious level of activity, including the possibility of launching astronauts on the U.S. space shuttle and possibly developing its own manned program. To date, however, the Japanese space program has focused on development of launch vehicles, and communications, weather, and scientific satellites. As listed in Table 12, by the end of 1984 they had successfully completed 27 launches (although two of the satellites did not go into the proper orbit). There are two organizations involved in launching satellites in Japan: the National Space Development Agency (NASDA), and the Institute of Space and Astronomical Science (ISAS).

Japan uses a mixture of U.S. and Japanese technology in its space activities. Some Japanese satellites have been purchased from U.S. aerospace companies, while others were built by Japanese firms subcontracting with U.S. companies. During the early years of the program, some orbital launches were provided by the United States (and these are not listed in Table 12) but NASDA now relies on the "N" launch vehicle which is manufactured in Japan under license from the McDonnell-Douglas Corp. A smaller rocket, called the Mu, is the one used primarily by ISAS for scientific satellites. The ISAS launch facility is on the island of Uchinoura, 900 kilometers southwest of Tokyo. NASDA launches from Tanegashima, an island south of Uchinoura.

Like ESA, Japan is likely to offer stiff economic competition to the United States, but not in terms of providing launch services. Rather,

Japan seems likely to compete in the area of space technology itself, particularly communications satellites and associated ground stations. For example, in 1977, the Japanese launched the first experimental communication satellite to operate at the frequencies of 30/20 Gigahertz. Most communication satellites today operate at lower frequencies, and those bands are becoming congested; 30/20 GHz technology is expected to be the wave of the future. In the United States, policy disputes over whether the Government or private industry should pay for developing advanced communication satellite technology such as this slowed development of U.S. technology, while the Japanese forged ahead. Their first operational 30/20 GHz satellite, CS 2, was launched in February 1983.

Development of communications satellites in Japan did not take place without difficulties, however. In 1979 and 1980, Japan lost two communications satellites (Ayame 1 and 2) after launch. The first satellite impacted the upper stage of its launch vehicle after separation, and the second was lost when the apogee kick motor used to place the satellite in geostationary orbit malfunctioned. In the latter case, the kick motor had been purchased from a U.S. company, and the Japanese subsequently indicated that they would develop their own kick motors for the future.

In 1981, the Japanese successfully launched the first improved version of the "N" launch vehicle, "N II", which can place 350 kilograms in geostationary orbit. They also announced plans to develop an H-1 vehicle which will be able to place 550 kilograms in geostationary orbit, and will use liquid hydrogen/liquid oxygen fuel. The 1969 agreement with the United States which allows access to launch vehicle technology prohibits Japan from transferring that technology to third countries and from launching satellites for third countries without prior agreement from the United States. Because of

this latter provision, Japan is not seen as a near-term launch competitor to the United States. Japan is planning to develop an H-2 launch vehicle, which will be more capable than the H-1 (two tons to geostationary orbit) and will be built entirely by Japan. This will relieve them of the restrictions placed on them by the 1969 agreement with the United States.

In the payload area, Japan has ambitious plans for the future as well. Among the approved programs are two missions to Halley's Comet, planned for launch in 1985. The first is called Sakigake, and will primarily be used as a test of an improved version of the Mu rocket which will launch the primary Japanese Halley's Comet probe, Planet A. As noted earlier, Japan, ESA and the Soviet Union are developing a cooperative agreement for exchange of data from their individual Halley's comet probes. Japan is also planning to send a probe to the Moon in 1987 which will first conduct orbital operations, and then deliberately crash into the lunar surface.

Other approved programs focus on developing more advanced communications, meteorological, and remote sensing satellites. In the latter category, the ERS satellite is scheduled for launch in 1990 (originally a 1986 launch date had been proposed) and will help explore for oil and mineral resources. Current plans call for the satellite to carry a synthetic aperture radar, a stereo camera, and visible and infrared radiation measurement systems. Also planned is a Marine Observation Satellite for launch in 1985 to study ocean surface temperatures.

They have also discussed a proposal for constructing a "mini-shuttle." Smaller than the U.S. space shuttle, the Japanese version would have most of the shuttle's basic features, including reusability, and could carry a crew of four. This proposal is in the very early stages of discussion and has not been approved. The Japanese are in the process of selecting one

or more persons to fly with Japanese payloads on the U.S. space shuttle. The first is expected to fly on a shuttle mission in 1988.

Japan has indicated a strong interest in participating with NASA in development of a space station, and has chosen Mitsubishi Heavy Industries as prime contractor for building a pressurized module which will be affixed to the U.S. space station. Japan has agreed to spend $1 billion over 10 years in support of the space station program.

In 1981 the Japanese raised the possibility of launching military reconnaissance satellites and using communications satellites to support their Self Defense Forces. The 1969 space cooperation agreement with the United States requires Japan to use U.S.-derived space technology only for peaceful purposes, and a 1969 resolution passed by the Diet also states that Japan will engage only in "peaceful" space activities. There is a continuing debate over whether reconnaissance and communications satellites would be counted as "peaceful" even though they are used by the military, since they are non-aggressive. In 1983, the Japanese Government approved plans for the military to use the CS2 communications satellite, but internal debate in Japan continues.

TABLE 12. JAPANESE SPACE LAUNCHES 1970-1984*

Spacecraft	Launch Date**	Launch Site†	Comments
Osumi Lambda 4S-5	Feb. 11, 1970	U	Test flight
Tansei MS-T1	Feb. 16, 1971	U	Test flight
Shinsei SS-1	Sept. 28, 1971	U	Science
Denpa REX SS-2	Aug. 19, 1972	U	Successful launch; payload failed
Tansei 2 MS-T2	Feb. 16, 1974	U	Test flight
Taiyo SRATS	Feb. 24, 1975	U	Science.
Kiku ETS 1	Sept. 9, 1975	T	Test of new N launch vehicle
Ume ISS	Feb. 29, 1976	T	Launch success, payload failure (for science)
Tansei 3 MS-T3	Feb. 19, 1977	U	Engineering test
Kiku ETS 2	Feb. 23, 1977	T	First Japanese launch to geostationary orbit; test satellite
Kyokko (EXOS A)	Feb. 4, 1978	U	Science
Ume 2	Feb. 16, 1978	T	Ionospheric sounding
Jikiken (Exos B)	Sept. 16, 1978	U	Science
Ayame 1 (ECS-1)	Feb. 6, 1979	T	Failed to reach geostationary orbit
Hakucho (Corsa B)	Feb. 21, 1979	U	Science
Tansei IV	Feb. 17, 1980	U	Test satellite
Ayame 2 (ECS-2)	Feb. 22, 1980	T	Failed to reach geostationary orbit
Kiku-3 (ETS-4)	Feb. 11, 1981	T	Engineering test
Hinotori (Astro A)	Feb. 21, 1981	U	Science
Himawari 2	Aug. 10, 1981	T	Weather
Kiku-4	Sept. 3, 1982	T	Engineering test
Sakura (CS-2A)	Feb. 4, 1983	T	30/20 GHz communications satellite
Hinotori (Astro B)	Feb. 20, 1983	U	Science
Sakura (CS-2B)	Aug. 5, 1983	T	30/20 GHz communications satellite
Yuri 2A	Jan. 23, 1984	T	Operational 30/20 GHz communications
EXOS C	Feb. 14, 1984	U	Science
Himawari 3	Aug. 3, 1984	T	Weather

* Does not include launches of Japanese satellites by other countries. For launch failures prior to 1977, see World Wide Space Activities (House Science and Technology Committee, 1977), p. 203. Data for the table were taken from that publication, plus Japanese press announcements, and U.S. trade publications such as Aerospace Daily.

** Launch dates are in Greenwich Mean Time, not local time.

† U = Uchinoura; T = Tanegashima.